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JOURNAL OF Paleontology

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JOURNAL OF PALEONTOLOGY

JOSEPH A. CUSHMAN, *Editor*

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DECEMBER 1927

A METHOD OF ASSIGNING NUMERICAL AND PERCENTAGE VALUES TO THE DEGREE OF ROUNDNESS OF SAND GRAINS

E. P. Cox

"How round is a rock?" This is a question that the geologist is often forced to ask himself when he wishes to consider the amount of erosion that a stone has received, and he usually finds it a very difficult question to answer definitely. But he will find it even more difficult to answer the question "How round is a sand grain?"

The customary way of indicating the roundness of a sand grain is to say merely that it is "well rounded," "fairly well rounded," "subangular," or "angular"—as, for instance, have Mortimore and Trowbridge.[1] But how are two individual workers to select the same division point between any two of the classes named? What one person might call "subangular" another might call "angular" and still another might call "fairly well rounded." So for any real comparison there must be some way of actually measuring this "degree of roundness."

Chester K. Wentworth[2] has given this question considerable study and has devised some methods of assigning definite numerical values to the degree of roundness of cobblestones.[3] By one of these methods he divides the smallest radius of "developed" curvature of the pebble by the mean radius of curvature, and plots this value against the value obtained by dividing the greatest radius of curvature by the mean radius. That is, he plots

$$\frac{r_1}{R} \text{ against } \frac{r_2}{R},$$

where r_1 is the radius of curvature of the "sharpest" developed edge and r_2 is the radius of curvature, in the most convex direction, of the flattest "developed" face or portion of the stone. In the other method he employs the formula

$$\frac{r_1}{\frac{1}{2}D} = R.$$

[1] "Correlation of Sands by Sedimentary Analysis," *Econ. Geol.*, vol. 20, no. 5 (August, 1925), p. 405.

[2] "A Laboratory and Field Study of Cobble Abrasion," *Jour. of Geol.*, vol. 29 (1919), p. 507.

[3] "A Method of Measuring and Plotting Shapes of Pebbles," *U. S. G. S. Bulletin 730C.*

R is here the "roundness" value; r_1 is, as before, the radius of the "sharpest developed curvature," and D is the diameter of the pebble starting from the point where r_1 was measured. For a complete discussion of these methods, together with means of making the measurements, the choice of gauges, and so forth, the reader is referred to the original articles. It is only necessary to point out here the extreme difficulty of measuring these angles on very small grains (it being impossible to use gauges as Wentworth suggests for pebbles), and also to call attention to the fact that, by this method, in any case where the "sharpest developed face" is a sharp angle, the value for the roundness of the pebble is zero, regardless of the shape of the rest of the specimen. This is well and good for Mr. Wentworth's purpose, for he apparently takes these sharp "developed edges" as an indication that the pebble has had no wear at all; and consequently his factor, which is in reality a factor of wear, should be zero. In the case, however, of the arkosic sands that the writer was interested in examining, there were very few grains that did not show at least one, and often many, such sharp angles. Consequently, these methods were useless for this problem, and another method had to be devised.

By "roundness" let us understand that we mean either the sphericity of a three-dimensional body or the circularity of a two-dimensional figure. The sphericity of a three-dimensional body may be expressed by the degree to which the ratio of its volume to its surface approaches the same ratio for a sphere; and if we could make such measurements on our grains, we would at once have a measure of their roundness. But while the volume of a grain may be fairly easily measured, the measurement of the surface is a much more difficult problem. If, however, we take a large number of random sections through a number of grains, the average of these sections will be the average section of the average grain; and the degree to which this average section approaches a circle will be the measure of the roundness of the grains. In this case, of course, the roundness is measured by the degree to which the ratio of the area to the circumference approaches the same ratio for a circle, and this value lends itself very readily to measurement.

Expressed mathematically,

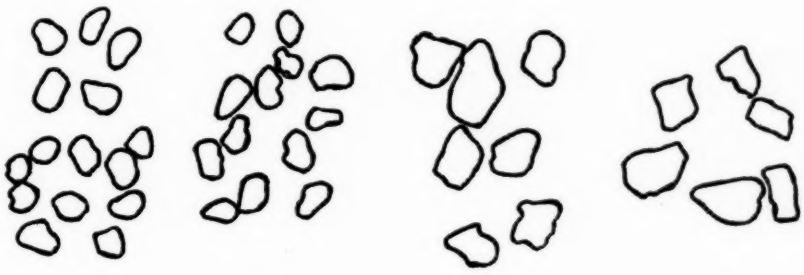
$$\frac{\text{area}}{(\text{perimeter})^2} = \text{a constant},$$

which is $\frac{1}{4}\pi$ for a circle. Therefore, if we multiply the equation by 4π we will have,

$$\frac{\text{area } 4\pi}{(\text{perimeter})^2} = K .$$

K is a constant that is dependent upon the shape of the figure, being 1 for a circle and less than 1 for any other shape; but it is the same for all figures of the same shape; regardless of size. That is to say, it means that a small circle is just as round as a large circle but no more so. Furthermore, the value of K for a figure of any given shape represents the percentage ratio that the area of the figure holds to the area of a circle with the same perimeter. That is, for example, in the case

of the square, where the constant is 0.785, it means that a square contains just 78.5 per cent of the area that a circle with the same perimeter would contain. Likewise, any right isosceles triangle has a roundness of 0.54 or contains 54 per cent of the area that a circle with the same perimeter would contain. In other words, this constant K gives the percentage roundness of the figure.



D	E	F	G
"rounded"	"fairly well rounded"	"subangular"	"angular"
0.96 to 0.81	0.97 to 0.74	0.92 to 0.86	0.83 to 0.60
av. 0.902	av. 0.85	av. 0.88	av. 0.76

FIG. 1

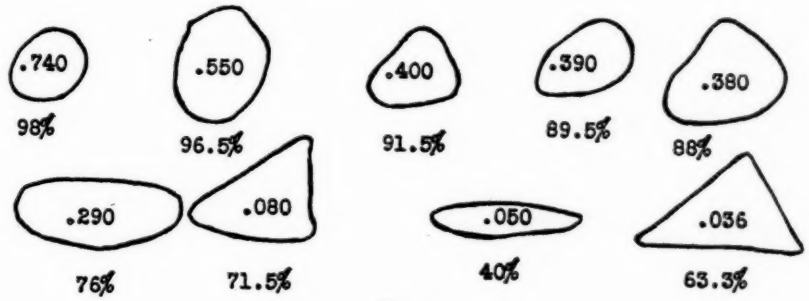


FIG. 2

D, E, F, and G of Fig. 1 are tracings of photographs published by Trowbridge and Mortimore* together with their classification. The numbers are those that would have been given by the present system of classification.

* *Loc. cit.*, p. 1.

In order to measure these values for a set of grains, it is only necessary, where thin-sections have been made, to project the image of the thin-section on a screen, or where a photograph has been taken of the detrital material, to project the image of the photograph on the screen, where it may be traced or measured directly. Or the grains may be sprinkled over a lantern slide that has been previously covered with glue or a suitable cement, the slide inserted in a projection camera, and the image obtained on the screen. A camera lucida may also be used but is usually much slower than the methods described above.

The area is measured by means of a planimeter; and the perimeter, by means of a cyclometer-map measurer. The writer mounted his map-measurer so that it took the place of the pointer of the planimeter; then by a single tracing of the outline, both the perimeter and the area of the figure were obtained; and by setting

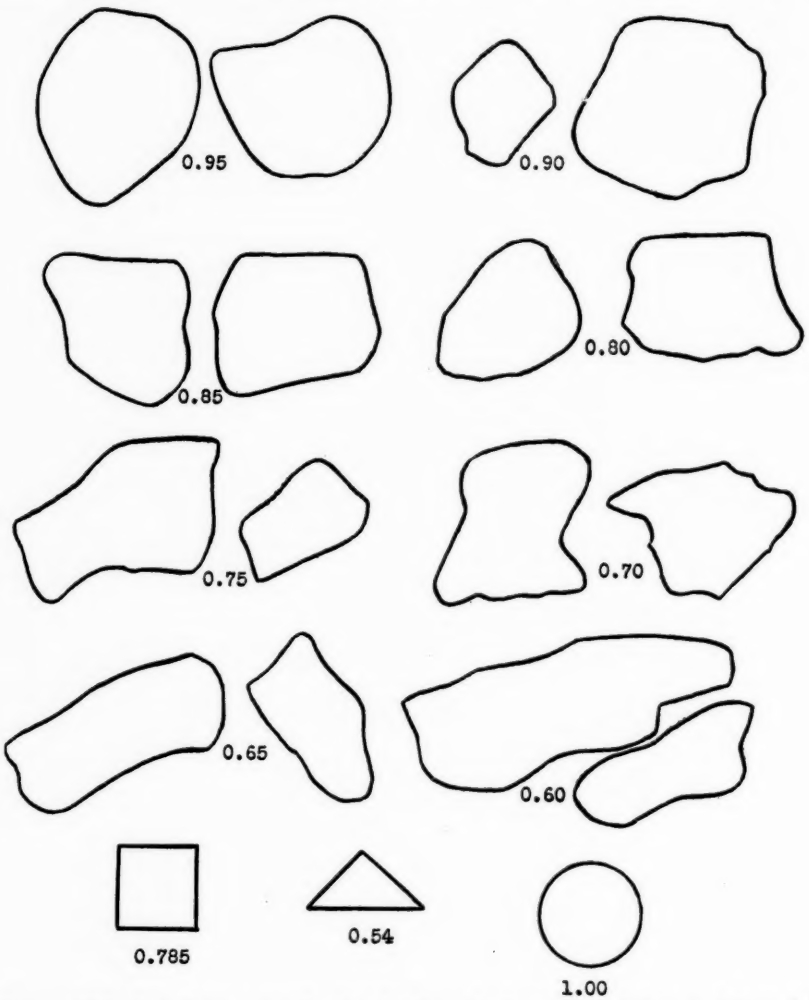


FIG. 3—This plate shows a couple of grains for each of a number of degrees of "roundness" together with some simple geometrical forms for the purpose of comparison and reference.

these values on the slide rule, the roundness could be read off directly. It thus required only from twenty seconds to a minute to measure accurately the roundness of any given grain.

The eye soon becomes trained so that the operator can estimate the roundness of a given grain to within 4 or 5 per cent in most cases. It is then necessary to

measure only the doubtful grains or make an occasional measurement for the purpose of checking the estimates.

The disadvantage of the system lies in the fact that where grains that have a decidedly tabular form, such as mica particles, are to be measured, it is necessary to imbed the material in some supporting medium and cut a thin section at random in order to insure a true sample of the shapes.

The principal advantages of the system are that it is simple, accurate, applicable to all sizes and shapes of grains, and will give numerical and uniform results in the hands of different operators and will thus serve as a true basis of comparison.

Figures 1, 2, and 3 are inserted for the purpose of comparing the percentage system with those previously discussed.

Figure 2 shows the outlines published by Wentworth, and inclosed within the outlines are the values for roundness that he assigned to the given figure. The percentage roundness by the present system is given just under each outline.

It will be noticed in figure 1 that by the percentage-roundness system, *e* and *f* should be reversed as to degree of roundness. This is because the grains in *f* are more equant than those in *e*. Again, the Wentworth values for roundness would arrange the outlines in the same manner as the percentage-roundness system with the exception of the last two where the percentage roundness of the last figure is larger than that of the preceding one.

DISTINCTIONS AMONG CERTAIN GENERA OF LARGER FORAMINIFERA FOR THE FIELD GEOLOGIST OF THE EAST INDIES

I. M. VAN DER VLERK AND R. E. DICKERSON

The lack of natural exposures in many parts of the East Indies renders the obtaining of stratigraphic data both costly and tedious. Pits must be dug in the marls of certain areas, and from strata exposed in them knowledge concerning the stratigraphy is gained. As an aid to stratigraphy, the so-called "larger" foraminifera are highly important, for the limited generic range of this group in the East Indian Tertiary gives the field geologist an effective tool. If he can recognize the genera in the field, the strata can be approximately placed stratigraphically.

The Eocene is characterized by the presence of *Discocyclina*, (formerly called *Orthophragmina*) and *Nummulites* (*Lepidocyclina*, *Miogypsina*, *Cycloclypeus*, and *Spiroclypeus* absent); the Oligocene by the presence of *Lepidocyclina* and *Nummulites* (*Spiroclypeus*, *Miogypsina*, *Cycloclypeus*, and *Discocyclina* absent); the Miocene by the presence of *Lepidocyclina*, *Miogypsina* and *Spiroclypeus* and certain species of *Cycloclypeus* (*Nummulites* and *Discocyclina* absent); and the Pliocene by the absence of larger Foraminifera, though *Cycloclypeus* may occur here since this genus has a living representative. Thus it is seen that the generic characters of these six forms are highly valuable; and their field determination, if the specimen is a large- or medium-sized one, is generally possible.

Only those criteria will be presented here which will aid the field geologist. No elaborate equipment is needed, a knife, hammer, hand lens, candle, matches, a flat file, and a small whetstone being the only tools necessary. In the East Indies, the larger Foraminifera occur frequently in marls and soft shales, from which they are easily isolated. In such cases results can be had with certainty. In compact limestone some of the distinctions described below cannot always be obtained.

Rough vertical sections can be made readily by pressing the knife blade firmly across the center of the fossil; and, unless the interior is calcified, this section is useful. The surface of the section should be wet and studied with a hand lens. A horizontal section may sometimes be obtained by heating the fossil in a candle flame and then striking the edge with a hammer. This method works well with *Nummulites* and was used by Verbeek. In hard rocks rough sections for field study may be made by smoothing down on a flat file and then polishing on a whetstone. The filed surface, if wet, will frequently suffice without polishing.

Stratigraphic divisions applicable to the east coast of Borneo are indicated in Table I. In a general way, A is regarded by most workers in the East Indies as Oligocene; B, C, D, as Miocene; and E and F as Pliocene. This table is useful only

in the East Indies and is in no sense intended to indicate world-wide generic changes. At present, zones E and F are the most difficult to distinguish, as their recognition is chiefly based on the absence of certain genera and species—a dangerous criterion but one that must be used in our present state of knowledge. Thorough collecting and study in the field is necessary, and the stratigraphy must not be neglected by the geologist.

In some cases the field geologist in trying to determine one of these genera will be in doubt whether to refer the form to one or to another genus, as some species are transitional. These can be recognized only by the specialist. Only the most marked generic characteristics are discussed below, and some of these are not

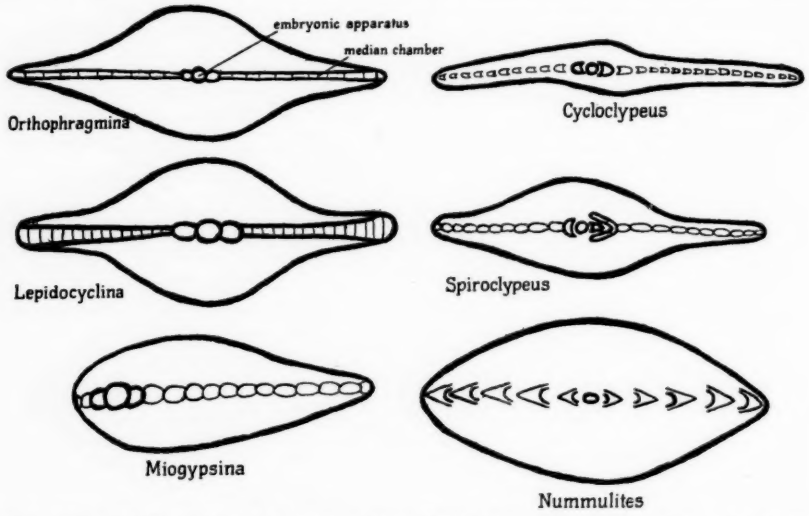


FIG. 1.—Vertical sections of *Discocyclina* (*Orthophragmina*), *Miogypsina*, *Cycloclypeus*, *Spiroclypeus*, and *Nummulites* showing the nature of the median chambers.

always common to all species of a given genus. This is especially true of *Discocyclina* (*Orthophragmina* formerly used), *Lepidocyclina*, and *Nummulites*, which have numerous species. The external aspect of all the described genera is discoidal or lenticular. In some cases it is possible for a specialist to distinguish the different genera by their external characters, but this requires long experience and even then errors are frequent. On this account, the internal characteristics are emphasized.

DISCOCYCLINA

The horizontal section of the median chamber plane (fig. 3) shows an arrangement of the chambers in concentric rings (similar to *Lepidocyclina;* different from *Miogypsina*, *Spiroclypeus*, and *Nummulites*). These chambers are rectangular (similar to *Cycloclypeus;* different from *Lepidocyclina*) and have their greater dimension parallel to the medial axis. The embryonic chambers are immediately surrounded by a closed ring of chambers (different from *Cycloclypeus*).

The vertical section (figs. 1 and 2) shows a distinctly-set-off median chamber plane, the median chambers being separated from the lateral chambers by a well-marked partition (different from *Cycloclypeus*, *Spiroclypeus* and *Nummulites*). This partition between median and lateral chambers is very thin (different from *Lepidocyclina*). As a rule the median chambers are wider than high, especially near the periphery (different from *Lepidocyclina*). The lateral chambers are arranged nearly "pile on pile" (different from *Miogypsina*).

Certain species of *Discocyclina* have a central dome and a surrounding shallow moat. This only occurs among the other genera in the case of two or three species of *Spiroclypeus*. This is a good external character. Certain species have raised radial ribs on the test. This is found in some species of *Discocyclina* (exception: *Lepidocyclina martini* Schlumberger) and hence marks the genus in these cases.

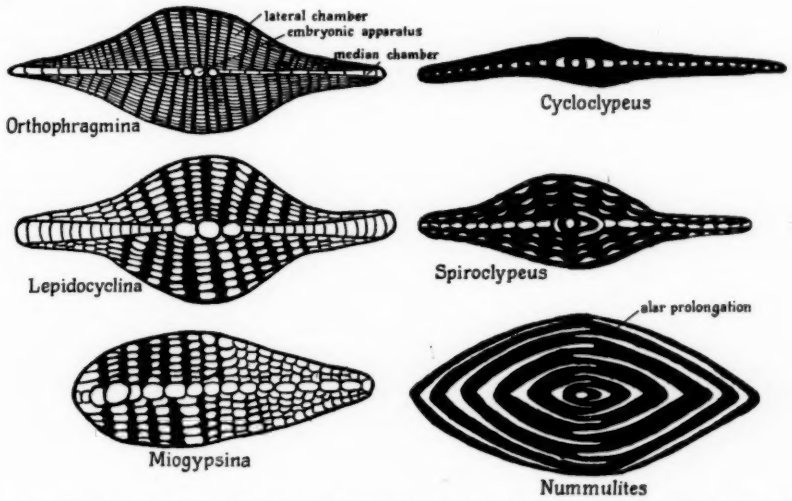


FIG. 2.—Vertical sections of six larger foraminifera showing lateral and median chambers

LEPIDOCYCLINA

The horizontal section (fig. 3) shows an arrangement of the median chambers similar to those of *Discocyclina* and *Cycloclypeus*, viz., in concentric rings (different from *Miogypsina*, and *Spiroclypeus*, and *Nummulites*). The form of these chambers is, however, spatulate, hexagonal, or lozenge-shaped (similar to *Miogypsina*: different from *Discocyclina*, *Cycloclypeus*, *Spiroclypeus*, and *Nummulites*). The embryonic apparatus of the megalospheric forms with diameters larger than 15 mm. (characteristic for the lower part of the *Lepidocyclina*-bearing Tertiary) has a second chamber, which entirely surrounds the initial chamber (sub-genus *Eulepidina*); the smaller forms have an embryonic apparatus in which the second, reniform chamber only partly encircles the initial chamber (sub-genera *Amphilepidina* and *Nephrolepidina*). The other sub-genera, well known in the American Tertiary, are not, or are seldom, represented in the Tertiary of East Asia and Australia. The

vertical section (figs. 1 and 2) shows a very distinct medial portion set off from the lateral chambers (similar to *Discocyclina;* different from *Cycloclypeus, Spiroclypeus,* and *Nummulites*) by a thick partition (different from *Discocyclina*). As a rule the height of the median chamber plane increases strongly from the center to the periphery (different from *Discocyclina* and *Miogypsina*).

Miogypsina

Most species of this genus are far too small for field determination. A few of the larger forms attain the size of 3–6 mm., that is, as large as small specimens of *Lepidocyclina.* The most marked characteristic of the genus, visible as well externally as in horizontal and vertical sections, is the eccentricity of the embryonic part (similar to some species of *Spiroclypeus;* different from *Discocyclina, Lepidocyclina, Cycloclypeus,* and *Nummulites*). The horizontal section (fig. 3) shows hexagonal or mostly lozenge-shaped median chambers (different from *Discocyclina, Cycloclypeus, Spiroclypeus,* and *Nummulites*). The vertical section (figs. 1 and 2) shows that there is not such a definite partition between the median-chamber plane and the lateral chambers as in the case of *Discocyclina* and *Lepidocyclina.*

Cycloclypeus

The horizontal section (fig. 3) shows concentric annuli of median chambers (similar to *Discocyclina* and *Lepidocyclina;* different from *Miogypsina, Spiroclypeus,* and *Nummulites*), which are rectangular (similar to *Discocyclina;* different from *Lepidocyclina*). The first embryonic chambers are not immediately surrounded by the closed annuli; first discontinuous layers of median chambers are interpolated (different from *Discocyclina*). As a rule the median chambers are much broader than those of *Discocyclina.*

The vertical section (figs. 1 and 2) shows a single layer of median chambers, covered-in above and beneath by compact plates of shell, which decrease in thickness from the center to the periphery (different from *Discocyclina, Lepidocyclina, Miogypsina, Spiroclypeus,*[1] and *Nummulites*). These shelly plates are formed of a succession of superimposed lamellae, which partly are the alar prolongations of the annular septa.

Externally, certain species exhibit in top view a "Saturn-ring effect," that is, a small central dome and shallow surrounding moats. In that case the vertical section gives the impression of a string of beads.

Spiroclypeus

The horizontal section (fig. 3) shows a spiral (different from *Discocyclina, Lepidocyclina, Miogypsina,* and *Cycloclypeus*), which is divided by strongly curved primary walls into chambers, which are again subdivided into chamberlets by

[1] The difference between the genus *Spiroclypeus* and the genus *Heterostegina* is the absence of lateral chambers in the latter; therefore it is in most cases impossible to distinguish a vertical section of *Cycloclypeus* from those of the still-living *Heterostegina.*

secondary walls (different from *Nummulites*). These chamberlets are rectangular and are very similar to those of *Cycloclypeus*.

A vertical section (figs. 1 and 2) shows a "nummulitic" inner part: the median chambers of this part have alar prolongations and also their septa have alar prolongations, which always cover the earlier-formed parts of the shell (different from

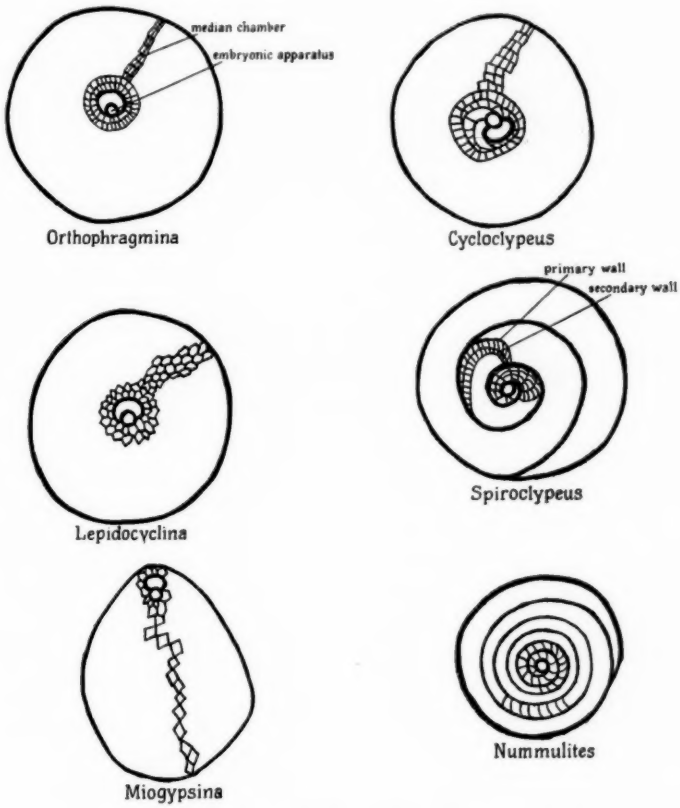


FIG. 3.—Horizontal sections of six larger foraminifera

Discocyclina, *Lepidocyclina*, and *Miogypsina*). Near the periphery the alar prolongations of the chambers are absent (different from *Nummulites*). The alar prolongations of the septa have at their inner sides excavations, which are the lateral chambers (different from *Cycloclypeus*).

In vertical section *Spiroclypeus* resembles *Cycloclypeus* closely. The median portion is somewhat less distinct but there is but little or no partition separating the median chambers from the lateral chambers. The median chambers are less distinct from the lateral chambers than in *Lepidocyclina*, and are formed by the modification of lateral chambers at the two angles of the test, as in *Nummulites*.

In horizontal section a distinct spiral is seen, but this is not usually visible externally. This genus externally resembles *Lepidocyclina* closely; and in the field would probably be identified as the latter genus, as the preparation of a careful horizontal section is not generally possible under field conditions.

Mummulites

The horizontal section (fig. 3) shows a spiral, which increases slowly in breadth[1] and is generally composed of more than four whorls[2] (different from *Discocyclina*, *Lepidocyclina*, *Miogypsina*, and *Cycloclypeus*). The spiral is divided into chambers by septa, which are only slightly curved[3] and which are not subdivided into chamberlets (different from *Spiroclypeus*).

A vertical section (figs. 1 and 2) shows a development of alar prolongations both of the median chambers and of the septa (different from *Discocyclina*, *Lepidocyclina*, *Miogypsina*, and *Cycloclypeus*) from the center to the periphery (different from *Spiroclypeus*).

This genus has no distinct medial portion but a vague medial region made up of rectangular lateral cells somewhat modified to conform to abrupt change in curvature at the angle on either side of the test.

The spiral arrangement of cells is shown only in horizontal section (similar to *Spiroclypeus;* different from *Discocyclina*, *Lepidocyclina*, and *Cycloclypeus;* spiral externally visible in *Operculina*, *Assilina*, and *Operculinella*). (See figure 2.)

The plates are diagrammatic, horizontal and vertical sections of the larger Foraminifera. The two keys which follow will enable the field geologist to work more effectively with rough horizontal or vertical sections. In general, horizontal sections are difficult to prepare from compact limestone; but if the entire form can be isolated from a shale or marl, workable sections may be obtained. Fortunately for the worker in the East Indies, foraminiferal marls and shales occur frequently enough so that the methods outlined are possible.

KEY FOR USE WITH HORIZONTAL SECTIONS

1*a*. Chambers arranged spirally in the adult
  2*a*. Chambers divided into chamberlets ..... *Spiroclypeus*
  2*b*. Chambers not divided into chamberlets ..... *Nummulites*
1*b*. Chambers not arranged spirally in the adult
  2*c*. Nucleoconch eccentric ..... *Miogypsina*
  2*d*. Nucleoconch central; median chambers annular
    3*a*. Median chambers hexagonal ..... *Lepidocyclina*
    3*b*. Median chambers rectangular
      4*a*. Early chambers spiral ..... *Cycloclypeus*
      4*b*. Early chambers annular ..... *Discocyclina*

[1] Different from the still-living genus *Operculina*.

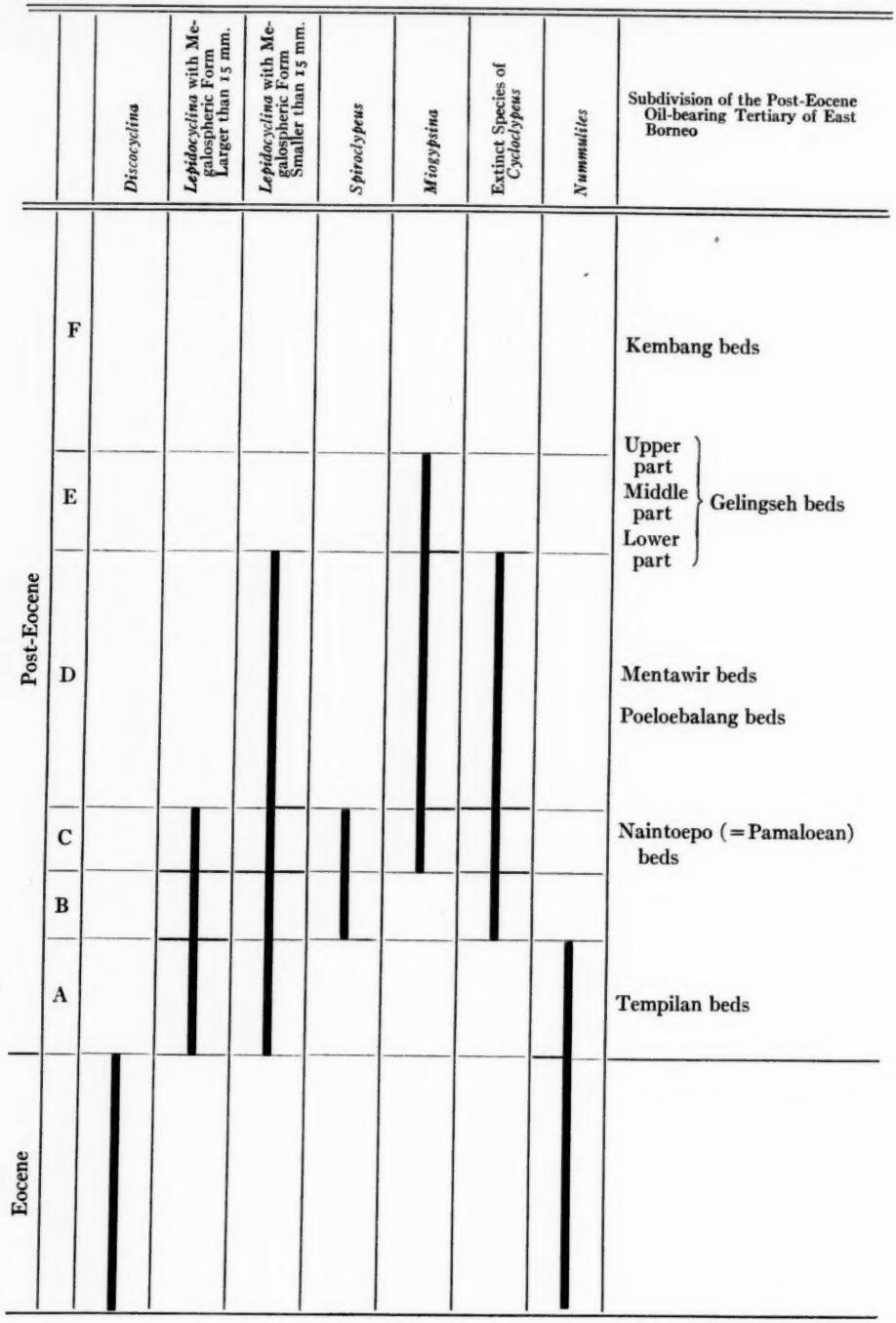
[2] Different from the still-living genera *Amphistegina* and *Operculinella* and also from *Operculina*.

[3] Different from *Amphistegina*.

KEY FOR USE WITH VERTICAL SECTIONS

1*d*. Median chambers with alar prolongations
  2*a*. With lateral chamberlets ..... *Spiroclypeus*
  2*b*. Without lateral chamberlets
    3*a*. Alar prolongations superposed, leaving no space ..... *Cycloclypeus*
    3*b*. Alar prolongations separated by the chamber cavity ..... *Spiroclypeus*
1*b*. Median chambers without alar prolongations
  2*c*. Nucleoconch central
    3*c*. Median zone thin, increasing little from center outward; lateral chambers small ..... *Discocyclina*
    3*d*. Median zone thick, thickening outward; lateral chambers large ..... *Lepidocyclina*
  2*d*. Nucleoconch eccentric ..... *Miogypsina*

TABLE I


Discocyclina
Lepidocyclina with Megalospheric Form Larger than 15 mm.
Lepidocyclina with Megalospheric Form Smaller than 15 mm.
Spiroclypeus
Miogypsina
Extinct Species of Cycloclypeus
Nummulites
Subdivision of the Post-Eocene Oil-bearing Tertiary of East Borneo
Post-Eocene
Eocene
F
E
D
C
B
A
Kembang beds
Upper part
Middle part
Lower part
Gelingseh beds
Mentawir beds
Poeloebalang beds
Naintoepo (=Pamaloean) beds
Tempilan beds

CORRECTION OF NAMES OF FORAMINIFERA

J. J. Galloway and Stanley G. Wissler
New York and Los Angeles

In our paper on "Pleistocene Foraminifera from the Lomita Quarry, Palos Verdes Hills, California," in volume 1, number 1, of this *Journal*, there are three errors in nomenclature which we wish to correct:

For the name "*Vaginulina robusta*, n. sp.," on page 48, preoccupied by Plummer (Univ. Texas Bull. No. 2644, April, 1927), we propose the name "*Vaginulina palosverdesensis*, n. sp."

For the generic name "*Carinina*," on page 51, preoccupied by Hubrecht (Rep. Voy. *Challenger*, Zoöl., vol. 19, 1887, p. 5), we propose the name "*Laticarinina*, n. gen."

Themeon decipiens, n. sp., on page 83, preoccupied by Costa, 1856, should be "*Themeon granulosus*, n. sp.," instead of "*Themeon granulosa*, n. sp.," as given on the explanation of plate 12.

Dr. G. Dallas Hanna and Dr. W. L. F. Nuttall have kindly called our attention to these errors.

A COLLECTION OF RECENT FORAMINIFERA TAKEN OFF SAN FRANCISCO BAY, CALIFORNIA[1]

G. D. HANNA AND C. C. CHURCH

In January, 1926, Mr. Herbert Brandt, collector for the Steinhart Aquarium made a trip to the fishing banks off San Francisco Bay, on one of the Paladini & Co. boats. His object was the collecting of living marine organisms for exhibition in the Aquarium. The fishermen were after flounders and necessarily dropped their nets to bottom. They worked back and forth over an area between Point Reyes and the Farallon Islands in water 75–85 fathoms in depth. Marine life in that area must be exceedingly abundant because most of the flat fishes sold in the San Francisco markets come from there.

A generous sample of bottom sediment brought up in the net was saved by Mr. Brandt and turned over to us for examination. It is composed chiefly of fine sand, and Foraminifera are abundant. The collection thus obtained is exceedingly interesting because of the bearing it has on the fauna of various geological horizons of Western North America. These latter are being used daily by geologists of many oil companies in correlation work and have assumed an economic importance hitherto enjoyed by no other group of fossil animals in the region. The paleontologists engaged in this activity are constantly wondering what forms may be living along the shores at the present time. The literature of the subject, although voluminous for the deep waters of the Pacific, is singularly lacking in records of the inshore Foraminifera of the continental shelf. Thus, during the voyage of the *Challenger*, 1873–76, much work was done in the Pacific, but the California Coast was not touched. San Francisco Bay was the home port of the U. S. S. *Albatross* for a great many years, but apparently no collections of Foraminifera were made from moderate depths along the adjacent shores. Possibly in departing on a cruise, the collecting apparatus was not in readiness for use until the inshore areas were passed, and, in returning, it was stowed away preparatory to entering port before the shallower depths were reached. The members of the scientific staff of this vessel did make an elaborate exploration of San Francisco Bay in 1912–13,[2] and many bottom samples were collected, but apparently the organisms of these have not been studied as yet. This work was extended as far out as the Farallon Islands, as the report on Mollusca shows,[3] but nothing is known of the disposition of any

[1] Contribution from the California Academy of Sciences; published by permission of the director.

[2] Sumner, Louderback, Schmitt, and Johnston. A report upon the "Physical Conditions in San Francisco Bay Based upon the Operations of the United States Fisheries Steamer *Albatross* during the Years 1912 and 1913." *Univ. Calif. Publ. Zoöl.*, vol. 14, no. 1 (1914), pp. 1–198, pls. 1–13, 20 text figures.

[3] E. L. Packard, "Molluscan Fauna of San Francisco Bay," *Univ. Calif. Publ. Zoöl.*, vol. 14, no. 2 (1918), pp. 199–452, pls. 14–60.

Foraminifera that may have been collected. It is unfortunate that this lack of knowledge of shallow-water forms exists, because the Pliocene and Pleistocene faunas are well known to many students.

This Farallon collection herein considered contains several species which are common in the late Tertiary of California, but its affinities certainly lie with existing Pacific Foraminifera. Several species are here reported from this part of the world for the first time. Although the assemblage must represent a very small part of the living fauna of the California coastal region, it serves to indicate the richness of the field in these forms, and undoubtedly further exploration will show many things of value to paleontologists as well as zoölogists.

The collection has been identified by means of books and papers which are accessible to most working paleontologists. Complete bibliographic references are not given, it being thought sufficient to refer only to a limited portion of the literature. The collection upon which the paper is based has been deposited in the California Academy of Sciences.

1. AMMODISCUS INCERTUS (d'Orbigny)

Ammodiscus incertus (D'ORBIGNY), H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 330, pl. 38, figs. 1–3.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 1, 1910, p. 73, figs. 95, 96 *a–b*.

Ammodiscus incertus is somewhat variable in size and the number of convolutions, but the single perfect specimen found here is typical of the species and measures about 3 mm. in diameter. It has ten whorls.

2. BIGENERINA NODOSARIA d'Orbigny

Bigenerina nodosaria D'ORBIGNY, H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 369, pl. 44, figs. 14–18.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 2, 1911, p. 27, figs. 46–48.

Abundant.

3. BOLIVINA PUNCTATA d'Orbigny

Bolivina punctata D'ORBIGNY, H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 417, pl. 52, figs. 18–19.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 2, 1911, p. 32, fig. 53.

The specimens found in the bottom sample agree very well with the figures cited.

4. BULIMINA PYRULA d'Orbigny

Bulimina pyrula D'ORBIGNY, H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 399, pl. 50, figs. 7–10.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 2, 1911, fig. 126.

The present form is slightly different from some of the earlier-described specimens in that it is slightly more elongate and the apical end is more pointed. It is common as a fossil in the Tertiary of California.

5. CASSIDULINA SUBGLOBOSA H. B. Brady

Cassidulina subglobosa, H. B. Brady, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 430, pl. 54, figs. 17 *a–c*.—Cushman, U. S. Nat. Mus. Bull. 71, pt. 2, 1911, p. 98, figs. 152 *a–c*.

Brady in the *Challenger* report lists this widely distributed form as a deep-water species, 120 fathoms being the shallowest record. This material came from not more than 85 fathoms. It is possible that currents may have brought it in from greater depths, but this is thought unlikely.

6. CORNUSPIRA FOLIACEA (Philippi)

Cornuspira foliacea (Philippi), H. B. Brady, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 199, pl. 11, figs. 5–9.—Cushman, U. S. Nat. Mus. Bull. 71, pt. 6, 1917, p. 24, pl. 1, fig. 1; pl. 2, fig. 1.

The single individual found is typical of the species and measures about 3 mm. in diameter. It has apparently not been reported from this region before.

7. CORNUSPIRA INVOLVENS (Reuss)

Cornuspira involvens (Reuss), H. B. Brady, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 200, pl. 11, figs. 1–3.—Cushman, U. S. Nat. Mus. Bull. 71, pt. 6, 1917, p. 25, pl. 1, fig. 2; pl. 2, fig. 2.

This shallow-water form is common in the material.

8. ROBULUS RENIFORMIS d'Orbigny

Cristellaria reniformis d'Orbigny, H. B. Brady, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 539, pl. 70, figs. 3 *a–b*.—Cushman, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 65, pl. 30, fig. 4; pl. 33, fig. 1.

This species most nearly resembles the figure given by Cushman and is in accord with his description. It is 2.5 mm. to 3 mm. in length and greatly compressed. Two specimens were found.

9. GAUDRYINA RUGOSA d'Orbigny

Gaudryina rugosa d'Orbigny, H. B. Brady, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 381, pl. 46, figs. 14–16.—Flint, Rep. U. S. Nat. Mus. 1897, p. 288, pl. 33, fig. 3.

Many typical specimens were found.

10. GLOBIGERINA BULLOIDES d'Orbigny

Globigerina bulloides d'Orbigny, H. B. Brady, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 593, pl. 77; pl. 79, figs. 3–7.—Cushman, U. S. Nat. Mus. Bull. 71, pt. 4, 1914, p. 5, pl. 2, figs. 7–9; pl. 9.

Abundant.

11. GLOBIGERINA INFLATA d'Orbigny

Globigerina inflata d'Orbigny, H. B. Brady, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 601, pl. 79, figs. 8–10.—Cushman, U. S. Nat. Mus. Bull. 71, pt. 4, 1914, p. 8, pl. 4, figs. 4–8.

Less common than the preceding.

may be due to the fact that either dredgings were not made near shore at this point or, if made, were not examined. Several specimens were found in our material, but the species could not be considered as abundant.

24. POLYMORPHINA ELEGANTISSIMA Parker and Jones

Polymorphina elegantissima PARKER and JONES, H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 566, pl. 72, figs. 12–15.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 90, pl. 38, fig. 1.

Only one perfect specimen of this species was found.

25. PULLENIA QUINQUELOBA (Reuss)

Pullenia quinqueloba (REUSS), H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 617, pl. 84, figs. 14, 15.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 4, p. 21, pl. 13, fig. 2 *a*, *b*.

Not very abundant.

26. PULVINULINELLA EXIGUA (H. B. Brady)

Pulvinulina exigua H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 696, pl. 103, figs. 13, 14.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 60, pl. 23, fig. 5.

Described first by Brady as a deep-water species, but the finding of a number of specimens in the Farallon material has reduced the depth to 80 fathoms or less.

27. CANCRIS OBLONGA (Williamson)

Pulvinulina oblonga (WILLIAMSON), H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 688, pl. 106, fig. 4 *a*, *b*, *c*.

Only one of this species was found, and the scarcity of references to it seems to indicate that it is rare.

28. QUINQUELOCULINA SEMINULUM (Linnaeus)

Serpula seminulum LINNAEUS, Syst. Nat. 12th ed., 1767, p. 1264, no. 791; 13th (GMELIN'S) ed., 1788, p. 3739, no. 2.

Quinqueloculina seminulum D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 303, no. 44.

Miliolina seminulum WILLIAMSON, Rec. Foram. Great Britain, 1858, p. 85, pl. 7, figs. 183–85. —H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 157, pl. 5, figs. 6 *a–c*.

Quinqueloculina seminulum (LINNAEUS), CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 6, 1917, p. 44, pl. 11, fig. 2.

Abundant.

29. REOPHAX DENTALINIFORMIS H. B. Brady

Reophax dentaliniformis H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 293, pl. 30, figs. 21, 22.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 1, 1910, p. 87, fig. 121.

Abundant.

30. REOPHAX PILULIFER H. B. Brady

Reophax pilulifer H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 292, pl. 30, figs. 18–20.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 1, 1910, p. 85, figs. 117–18.

Abundant.

31. TEXTULARIA GRAMEN d'Orbigny

Textularia gramen D'ORBIGNY, H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 365, pl. 43, figs. 9, 10.—FLINT, Rep. U. S. Nat. Mus. 1897, p. 284, pl. 29, fig. 5.

Abundant.

32. TRILOCULINA TRIANGULARIS (d'Orbigny)

Quinqueloculina triangularis D'ORBIGNY, Annales des Sci. Nat., vol. 7, 1826, p. 302, no. 34.
Miliolina triangularis (D'ORBIGNY), BAGG, U. S. Geol. Surv. Bull. 513, 1912, p. 31, pl. 4, figs. 3 *a*, *b*, *c*, *d*, *e*, and *f*.

This form closely resembles *M. trigonula* (Lamark) but is less sharply keeled. It has also been confused at various times with the early described *Miliolina seminulum* (Linnæus), and Brady uses the two names synonymously.

We have adopted the generic name *Triloculina* from Cushman's classification for similar forms. This large porcelaneous form is very abundant in the Farallon dredging and has been figured by Bagg from photographs (*op. cit.*) from the Pleistocene of San Pedro, California.

33. TROCHAMMINA INFLATA (Montagu)

Trochammina inflata (MONTAGU), H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 338, pl. 41, figs. 4 *a*, *b*, *c*.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 1, 1910, p. 121, figs. 188, *a*, *b*.

Trochammina inflata is often found in the shallower portions of open bays and is able to live in brackish water. Cushman stated that "there seem to be no published records for the occurrence of this species in the North Pacific." It is of common occurrence in the Farallon dredging.

34. CIBICIDES LOBATULA (Walker and Jacob)

Truncatulina lobatula (WALKER and JACOB), H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 660, pl. 93, figs. 1, 4, 5.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 31, pl. 15, fig. 1 *a*, *b*, *c*.

This highly variable species is found in all oceans and is usually a shallow-water dweller. It was common in the Farallon dredging.

35. CIBICIDES UNGERIANA (d'Orbigny)

Truncatulina ungeriana (D'ORBIGNY), H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 664, pl. 94, fig. 9 *a–d*.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 5, 1915, p. 36, figs. 39 *a*, *b*, *c* (pl. 17, fig. 2, is not like this species).

Only one individual of this species was found in the Farallon dredging.

36. UVIGERINA ANGULOSA Williamson

Uvigerina angulosa WILLIAMSON, H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 576, pl. 74, figs. 15–18.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, pl. 44, fig. 4.

This small form was found only sparingly in the finer material of the Farallon dredging.

37. UVIGERINA TENUISTRIATA Reuss

Uvigerina tenuistriata REUSS, H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 574, pl. 74, figs. 4–7.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 3, 1913, p. 95, pl. 42, fig. 4 *a–b*.

This form varies considerably in the length of test and number of chambers. It was common in the Farallon dredging.

SOME PENNSYLVANIAN OSTRACODA OF THE GLENN AND HOXBAR FORMATIONS OF SOUTHERN OKLAHOMA AND OF THE UPPER PART OF THE CISCO FORMATION OF NORTHERN TEXAS

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This paper will describe some of the Ostracoda of stratigraphic importance in the Glenn and Hoxbar formations of southern Oklahoma and in the upper part of the Cisco formation of northern Texas. The illustrations have been drawn by the writer with a camera lucida. The type fossils have been deposited at the U. S. National Museum.

Family LEPERDITIIDAE Jones (restricted)

Genus PARAPARCHITES Ulrich and Bassler, 1906

PARAPARCHITES INORNATA (McCoy)

Plate 32, figs. 1 *a*, *b*

Cythere inornata McCOY, Synops. Char. Carb. Foss. Ireland, 1843, p. 167, pl. 23, fig. 18.
Leperditia okeni, var. *inornata* JONES and KIRKBY, Ann. Mag. Nat. Hist., ser. 3, vol. 18, 1866, p. 44; Ann. Mag. Nat. Hist., ser. 4, vol. 15, 1875, p. 54, pl. 6, fig. 2; Ann. Mag. Nat. Hist., ser. 6, vol. 6, 1892, p. 303, pl. 16, fig. 2.

Test small, obliquely subovate, the longest diameter being from the antero-dorsal to the postero-ventral region at a low angle. The anterior is smaller than the posterior moiety. Length, 1 mm.; height, 0.96 mm.; thickness, 0.5 mm.

Cisco.—(Surface outcrop) shale just below Sedwick limestone, 2½ miles northeast of Coleman, Texas.

Family BEYRICHIIDAE Jones

Genus HOLLINA Ulrich and Bassler

HOLLINA GRAHAMENSIS Harlton, n. sp.

Plate 32, figs. 2 *a*, *b*

Shell, small, semiovate to semicircular, hinge line straight, cardinal angles moderately sharp, marginal frill small, protected by two rows of spines, one on edge and another within marginal frill. Valves with two nodes, the anterior subglobular, almost reaching the dorsal edge; the posterior almost the same size and gradually swelling out with the surface of the ventro-posterior portion. A moderate depres-

[1] Published by permission of the Amerada Petroleum Corporation. The writer wishes to express appreciation to Dr. R. S. Bassler for helpful suggestions and careful criticism.

sion of the surface occurs between and extends some distance beneath the nodes. Surface of the valves minutely granulose. Length, 1 mm.; height, 0.7 mm.; greatest thickness, 0.53 mm.

Upper Glenn.—(Surface outcrop) SW. ¼ of SE. ¼ of SE. ¼ of Sec. 12, T. 6 S., R. 1 E., Love County, Oklahoma, about 7 miles south of Ardmore. Holotype, U. S. National Museum, No. 71413.

HOLLINA GRANIFERA (Ulrich)

Plate 32, fig. 3

Bollia granifera ULRICH, Jour. Cincinnati Soc., Nat. Hist., vol. 13, 1891, pp. 205–6, pl. 12, figs. 12 *a*, *b*.

Shell comparatively large, oblique, back long, straight, with well-marked cardinal angles; anterior margin vertical above, then curving backward into a rather strongly convex ventral margin; posterior edge with a bold and nearly uniform curve. Free margins with a strong and wide concave frill, overhanging and extending some distance beyond the contact edges. Peripheral portion of frill obscurely crenulated. The generic loop-ridge oblique, with bulbous extremities, the anterior bulb very large, subglobular, reaching the dorsal edge; its surface is strongly papillose, the posterior bulb much smaller, situated at a distance nearly equaling its diameter from the dorsal edge; curved connecting portion of loop ridge-like, rather thin. Surface of valves minutely granulose. Length, 1.33 mm.; height, 0.82 mm.; greatest thickness of right valve, 0.4 mm.

Hoxbar.—(Surface outcrop) NW. cor. of Sec. 20, T. 5 S., R. 1 E., Carter County, Oklahoma, about 2 miles south of Ardmore.

HOLLINA TRICOLLINA (Ulrich)

Plate 32, figs. 4 *a*, *b*

Beyrichia tricollina ULRICH, Jour. Cincinnati Soc. Nat. Hist., vol. 13, 1891, p. 189–90, pl. 12, fig. 6.

Shell, suboblong, semiovate, moderately convex, with a long, straight hinge line, and very wide marginal frill. Without the frill the shape of the valves might be called semicircular, were it not for a slight prominence in the postero-ventral portion of the curve. Surface exhibiting three rounded tubercles, one near the postero-cardinal angle, another, perhaps twice as large, near the center of the dorsal margin, and the third, smaller than either, situated between and a little beneath them. Besides these two, slight swellings of the surface may be noticed in the postero-ventral fourth of the valves. A moderate depression of the surface occurs between and extends some distance beneath the largest and smallest of the tubercles. Length, 1.33 mm.; height with frill, 0.82 mm.; height without frill, 0.7 mm.

Lower Glenn.—(Surface outcrop) NW. ¼ of NW. ¼ of NE. ¼ of Sec. 16, T. 6 S., R. 2 E., Love County, Oklahoma, about 8½ miles south of Ardmore.

Family KLOEDENELLIDAE Ulrich and Bassler

Genus JONESINA Ulrich and Bassler

JONESINA CRATERIGERA (Jones and Kirkby)

Plate 32, figs. 5 *a*, *b*

Beyrichia craterigera JONES and KIRKBY, Geol. Mag., vol. 3, December 3, 1886, p. 439, pl. 12, figs. 7 *a*, *b*.

Shell obliquely oblong; dorsal and ventral borders nearly parallel, extremities rounded with a forward swing, a deep sulcus near the anterior third, and another passing forward to the antero-dorsal angle. Valves convex, the right overlapping the left very strongly, lateral contour cuneiform, shell thick, surface reticulated. Length, 1 mm.; height, 0.5 mm.; thickness, 0.44 mm.

Lower Glenn.—(Surface outcrop) center of north line of Sec. 14, T. 5 S., R. 1 E., Carter County, Oklahoma, about 2 miles south of Ardmore.

JONESINA ARCUATA (Bean)

Plate 32, figs. 6 *a–c*

Cypris arcuata BEAN, Ann. Mag. Nat. Hist., vol. 9, 1836, p. 377, woodcut, fig. 55.
Beyrichia arcuata JONES and KIRKBY, Geol. Mag., vol. 3, December 3, 1886, p. 438, pl. 12, figs. 12–14.

Shell subovate in outline, with convex valves; the dorsal margin straight, the ventral margin arched, the posterior end smallest (lowest). A deep sulcus marks the anterior half of the valves, and in front of it, close to the antero-dorsal angle, there is often a small, nearly obsolete notch that is more strongly marked on internal casts. The valves are rimmed, and the surface is polished and finely punctate. Length, 0.7 mm.

Lower Glenn.—(Surface outcrop) SW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ of Sec. 16, T. 6 S., R. 2 E., Love County, Oklahoma, about $8\frac{1}{2}$ miles south of Ardmore.

JONESINA BRADYANA (Jones and Kirkby)

Plate 32, figs. 7 *a*, *b*

Beyrichia bradyana JONES and KIRKBY, Geol. Mag., vol. 3, December, 3, 1886, pp. 438–39, pl. 12, fig. 11.

Shell small, subovate in form, with the left valve strongly overlapped by the right. It has a well-marked subcentral sulcus, and in some specimens a fainter and smaller anterior impression with a roundish boss between. Seen from above, the outline is compressed-ovate, pointed at the ends. Surface smooth. Length, 0.75 mm. Many specimens are relatively higher and shorter than the one figured.

Upper Glenn.—(Surface outcrop) $\frac{1}{4}$ mile north of SE. cor. of Sec. 9, T. 6 S., R. 2 E., Love County, Oklahoma, about 7 miles south of Ardmore.

Family KIRKBYIDAE Ulrich and Bassler

Genus GLYPTOPLEURA Girty

GLYPTOPLEURA COSTATA (McCoy)

Plate 32, figs. 8 *a*, *b*

Cythere costata McCoy, Syn. Char. Carb. Foss., 1844, p. 165, pl. 23, fig. 11.
Kirkbya costata Jones and Kirkby, Ann. Mag. Nat. Hist., ser. 3, vol. 18, 1866, p. 43.
Kirkbya costata Jones, Kirkby, and Brady, Mono. Brit. Foss. Biv. Entom. Pal. Soc., 1884, p. 89, pl. 7, fig. 17.
Kirkbya costata McCoy, Ann. Mag. Nat. Hist., ser. 5, vol. 15, 1892, pp. 186–87, pl. 3, figs. 13 *a*, *b*, 14 *a*, *b*; var., fig. 15.

Shell subovate or ovate-oblong, flat-sided, slightly higher behind, height more than half the length, thick-shelled, and strongly ribbed with subconcentric ridges. Dorsal border straight or nearly so, and over two-thirds of the maximum length, ventral border more or less convex, extremities rounded, the anterior smaller than the other, and both somewhat angular above. Subcentral pit circular, rather above the median line, and showing internally as a raised spot. Edge view (lateral contour) long ovate with flattened sides. The extreme anterior portion of each valve is smooth, but from near the center of that portion spring two strong ribs, one curving abruptly upward and the other downward, and then passing along the valves rather obliquely and sinuously to a point near the postero-ventral angle, where they curve to each other and join. Between them are two or three somewhat smaller but similar ribs, also free at their anterior ends, but connected at the other. Other ribs come in below, more or less parallel to the lowest of those just described, and still others come in above and fill up the triangular space between the upper large rib and the dorsal border, the highest rib being nearly as strong as the two first mentioned. There is considerable variation in the curvatures and connections of the riblets. Surface not reticulate. Length, 0.9 mm.

Upper Glenn.—(Surface outcrop) SW. $\frac{1}{4}$ of SE. $\frac{1}{4}$ or SE. $\frac{1}{4}$ of Sec. 12, T. 6 S., R. 1 E., Love County, Oklahoma, about 7 miles south of Ardmore.

Genus AMPHISSITES Girty

AMPHISSITES DATTONENSIS Harlton, n. sp.

Plate 32, figs. 9 *a*, *b*

Shell small, oblong subquadrate, with thick flattened edges, straight back, cardinal angles moderately sharp, posterior less sharp of the two, valves with a very small crescentiform ridge situated near the middle of the test. On the dorso-posterior portion is a very pronounced, almost straight vertical ridge. The marginal ridge, which likewise is well developed, runs parallel with the free edges, starts more or less directly below the vertical ridge, and gradually diminishes along the dorso-anterior portion. Surface finely reticulated. Small narrow pits near the middle of the ventro-anterior and posterior, likewise another small pit at the

posterior side at the central crescentiform ridge. Length, 0.8 mm.; height, 0.44 mm.; thickness, 0.4 mm.

Upper Glenn.—(Surface outcrop) NW. ¼ of NW. ¼ of NW. ¼ of Sec. 18, T. 5 S., R. 2 E., Carter County, Oklahoma, about 2 miles south of Ardmore. Holotype, U. S. National Museum, No. 71406.

AMPHISSITES CENTRONATA (Ulrich and Bassler)

Plate 32, figs. 10 *a*, *b*

Kirkbya centronata ULRICH and BASSLER, Proc. U. S. Nat. Mus. No. 1446, pp. 159–60, pl. 11, fig. 16.

Shell oblong subquadrate, with thick flattened edges, a long straight back, and rather sharp cardinal angles, the posterior angle the less sharp of the two. Valves with a prominent, large, rounded node situated very near the middle of the dorsal half. On each side of this is a smaller elevation surmounted by a thin, curved, vertical ridge in old examples. The marginal ridge, which likewise is well developed only in old specimens, is directly over the hinge but runs more or less within the free edges. Test rather finely reticulate. The margins, the ridges, and the surface ornamentation are all arranged more or less obviously in a concentric manner. "Pit" of moderate size, though readily distinguished from the meshes of the surface ornament, situated at the base of the medium node and very near the center of the valve. Length, 0.64 mm.; height, 0.37 mm.; thickness, 0.38 mm.

Hoxbar.—(Surface outcrop) N.W cor. of Sec. 20, T. 5 S., R. 1 E., Carter County, Oklahoma, about 4½ miles southwest of Ardmore.

Family BAIRDIIDAE?

Genus HEALDIA Roundy

HEALDIA OVERBROOKENSIS Harlton, n. sp.

Plate 33, figs. 1 *a–c*

Shell very small, dorsal margin nearly straight in the anterior and posterior halves, rounded near the middle point. Ventral margin straight but curving gradually into the rounded ends. The test in the dorsal view is wedgelike, the anterior end being thin and sharp, the posterior end swollen. The dorso-posterior slope is characteristic of the genus. On the outward posterior part of the left valve are two large spines; on the outward ventro-posterior part of the right valve is another large spine; and on the very outward dorso-posterior part is a horseshoelike ridge. Left valve larger, overlapping the right on all sides. Surface smooth. Length, 0.7 mm.; height, 0.36 mm.; thickness, 0.33 mm.

Lower Glenn.—(Surface outcrop) NW. ¼ of NW. ¼ of NE. ¼ of Sec. 16, T. 6 S., R. 2 E., Love County, Oklahoma, about 8½ miles south of Ardmore. Holotype, U. S. National Museum, No. 71412.

HEALDIA CANEYENSIS Harlton, n. sp.

Plate 33, figs. 2 *a–c*

Shell small, dorsal margin slightly curved in the anterior half, posterior half and middle gently curved. Ventral margin nearly straight but curving gradually into the well-rounded ends. The test viewed from above is wedgelike, anterior rather thin and sharp, posterior end thick with well-developed ridge. On the outward posterior portion of the swollen area large spines are developed. Left valve larger, overlapping the right on all sides. Surface smooth. Length, 1 mm.; height, 0.7 mm.; thickness, 0.5 mm.

Upper Caney, Lower Pennsylvanian (this member was included and termed "Springer" by Goldston, Jr., in the Lower Glenn formation). (Surface outcrop) SW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ of Sec. 16, T. 6 S., R. 2 E., Love County, Oklahoma, about $8\frac{1}{2}$ miles south of Ardmore. Holotype, U. S. National Museum, No. 71411.

HEALDIA OKLAHOMAENSIS Harlton, n. sp.

Plate 33, figs. 3 *a–c*

Shell very small, dorsal margin nearly straight in the anterior and posterior halves, and subangular near the middle point. Ventral margin straight but curving gradually into the rounded ends. The test in the dorsal view is wedgelike, the anterior being thin and sharp, the posterior end swollen. On the outward dorsoposterior part of the left valve is an inconspicuous ridge and on the outward posterior part of the swollen portion of the right valve are two spines. Left valve larger, overlapping the right on all sides. Surface smooth. Length, 0.72 mm.; height, 0.48 mm.; thickness, 0.32 mm.

Upper Glenn.—(Surface outcrop) SW. $\frac{1}{4}$ of SE. $\frac{1}{4}$ of SE. $\frac{1}{4}$ of Sec. 12, T 6 S., R. 1 E., Love County, Oklahoma, about 7 miles south of Ardmore. Holotype, U. S. National Museum, No. 71716.

HEALDIA CISCOENSIS Harlton, n. sp.

Plate 33, figs. 4 *a*, *b*

Shell comparatively very small, dorsal margin arched, gently curved in the anterior half, nearly straight in the posterior half, and rounded near the middle point. Ventral margin nearly straight but curving gradually into the rounded ends. The test viewed from above is wedgelike, anterior thin and sharp, posterior end thick with a rather inconspicuous ridge. On the outward posterior portion of the swollen area small spines are developed. Left valve larger, overlapping the right on all sides. Surface smooth. Length, 0.44 mm.; height, 0.32 mm.; thickness, 0.20 mm.

Cisco.—(Surface outcrop) shale just below Sedwick limestone, $2\frac{1}{2}$ miles northeast of Coleman, Coleman County, Texas. Holotype, U. S. National Museum, No. 71715.

HEALDIA BOGGYENSIS Harlton, n. sp.

Plate 33, figs. 5 *a*, *b*

This species differs from *H. ciscoensis* by having its dorso-anterior slope less conspicuously curved, by its more pointed anterior end, and by the absence of arching.

Upper Glenn.—(Surface outcrop) NW. ¼ of NW. ¼ of NW. ¼ of Sec. 12, T. 6 S., R. 1 E., Love County, Oklahoma, about 7 miles south of Ardmore. Cotypes, U. S. National Museum, No. 71717.

HEALDIA GLENNENSIS Harlton, n. sp.

Plate 33, figs. 6 *a*, *b*

Shell very small, dorsal margin nearly straight in the anterior and posterior halves and subangular near the middle point. Ventral margin straight but curving gradually into the rounded ends. The test in the dorsal view is wedgelike, the anterior end being thin and sharp, the posterior end swollen. On the outward dorso-posterior portion of each valve is a very inconspicuous node and on the outward ventro-posterior portion of each valve is a spine. Left valve larger, overlapping the right on all sides. Surface smooth. Length, 0.72 mm.; height, 0.45 mm.; thickness, 0.32 mm.

Upper Glenn.—(Surface outcrop) SW. ¼ of SE. ¼ of SE, ¼ of Sec. 12, T. 6 S., R. 1 E., Love County, Oklahoma, about 7 miles south of Ardmore. Holotype, U. S. National Museum, No. 71718.

Family BAIRDIIDAE Ulrich and Bassler

Genus BAIRDIA McCoy

BAIRDIA OKLAHOMAENSIS Harlton, n. sp.

Plate 33, fig. 7

Shell large and thick, subrhomboidal in outline, the point of greatest thickness being at the anterior upper half near the middle of the shell; overlapping dorso-posterior edge of left valve moderately thick, the ventral overlap strongest near the middle. Dorsal border arched, with the dorso-posterior slope more or less straight, dorso-anterior slope with small conspicuous curve near the middle. Ventral border curved; anterior extremity rounded, most prominent above, posterior extremity acuminate. Valves inequal, hingement formed by overlap of the left valve over the right. Surface evenly convex, smooth. Length, 1.4 mm.; height, 0.82 mm.; thickness, 0.54 mm.

Upper Glenn.—(Surface outcrop) NW. ¼ of NW. ¼ of NW. ¼ of Sec. 18, T. 5 S., R. 2 E., Carter County, Oklahoma, about 2 miles south of Ardmore. Holotype, U. S. National Museum, No. 71409.

BAIRDIA CISCOENSIS Harlton, n. sp.

Plate 33, fig. 8

Shell small, subrhomboidal in outline, length about half as much again the height. Dorsal border arched, dorso-posterior and anterior slope almost straight. Ventral border curved, anterior extremity very slightly curved, prominent above posterior extremity acuminate. Valves inequal, left valve overlaps the right strongly along the dorsal border and moderately along ventral. Surface evenly convex, smooth. Length, 0.76 mm.; height, 0.48 mm.; thickness, 0.36 mm.

Cisco.—(Surface outcrop) shale just below Sedwick limestone, 2½ miles northeast of Coleman, Coleman County, Texas. Cotypes, U. S. National Museum, No. 71719.

BAIRDIA TEXANA Harlton, n. sp.

Plate 33, fig. 9

Shell elongate, length about twice the height. Dorsal margin very slightly curved with the dorso-posterior slope curved, dorso-anterior slope straight. Ventral border straight or slightly concave, anterior extremity rounded, very prominent above, posterior extremity rounded. Dorsal overlap strong. Valves inequal, hingement formed by the overlap of the left valve over the right. Surface evenly convex, smooth. Length, 1.12 mm.; height, 0.52 mm.; thickness, 0.40 mm.

Cisco.—(Surface outcrop) shale just below Sedwick limestone, 2½ miles northeast of Coleman, Coleman County, Texas. Holotype, U. S. National Museum, No. 71720.

BAIRDIA GLENNENSIS Harlton, n. sp.

Plate 33, fig. 10

Shell elongate, length about two and one-half times the height. Dorsal border evenly curved, dorso-posterior and anterior slope straight or very slightly curved. Ventral border straight, anterior extremity rounded, bluntly pointed; posterior extremity rounded. The left valve overlaps the right strongly along the dorsal border, along the ventral border strongest near the middle. Surface evenly convex, smooth. Length, 1.73 mm.; height, 0.7 mm.; thickness, 0.5 mm.

Upper Glenn.—(Surface outcrop) ¼ mile north of SE. ¼ of Sec. 9, T. 5 S., R. 1 E., Carter County, Oklahoma, about 2 miles south of Ardmore. Holotype, U. S. National Museum, No. 71407.

BAIRDIA SUBELONGATA Jones and Kirkby

Plate 33, fig. 11

Bairdia subelongata JONES and KIRKBY, Jour. Geol. Soc. London, 1879, pp. 573–74, pl. 30, figs. 1–11, 16.

Shell elongate, length about three times the height. Dorsal border straight or very slightly concave and parallel (or nearly so) with the dorsal border. Anterior extremity broadly rounded, evenly so in many specimens, but sometimes most prominent above; posterior extremity bluntly pointed, being diagonally truncate,

as it were, above or below. Dorsal overlap moderate. Lateral contour about four times as long as wide, flat or flatly convex for a good central third, with pointed ends, the anterior being rather the most acute. Surface smooth. Length, 1.33 mm.

Upper Glenn.—(Surface outcrop) NW. ¼ of NW. ¼ of Sec. 18, T. 5 S., R. 2 E., Carter County, Oklahoma, about 2 miles south of Ardmore.

BAIRDIA HOXBARENSIS Harlton, n. sp.

Plate 33, fig. 12

Shell elongate, length about three times the height. Dorsal border straight or very slightly curved, with the dorso-posterior slope curved, dorso-anterior slope straight. Ventral border straight, anterior extremity rounded, most prominent above, posterior extremity rounded. Dorsal overlap moderate. Valves inequal, hingement formed by the overlap of the left valve over the right. Surface evenly convex, smooth. Length, 1.33 mm.; height, 0.53 mm.; thickness, 0.4 mm.

Hoxbar.—(Surface outcrop) NW. cor. of Sec. 20, T. 5 S., R. 1 E., Carter County, Oklahoma, about 2 miles south of Ardmore. Holotype, U. S. National Museum, No. 71408.

Family CYTHERELLIDAE Sars

Genus CYTHERELLA Jones

CYTHERELLA INCURVESCENS Jones and Kirkby

Plate 33, figs. 13 *a–d*

Cytherella incurvescens Jones and Kirkby, Scient. Trans. of Royal Dublin Soc., vol. 7, 1896, pp. 176–77, pl. 11, figs. 1–5.

Shell suboblong, rounded almost equally at the ends, the anterior end being usually the highest. The valves are more or less constricted; the ventral margin always, and the dorsal in some cases, being incurved. The overlap of the left valve by the right is moderate. Edge view nearly lenticular in some cases, lanceolate in others. Surface smooth. Length, 0.8 mm.; height, 0.4 mm.; thickness, 0.28 mm.

Upper Glenn.—(Surface outcrop) SW. ¼ of SE. ¼ of SE. ¼ of Sec. 12, T. 6 S., R. 1 E., Love County, Oklahoma, about 7 miles south of Ardmore.

Family CYTHERIDAE Zenker

Genus CYTHEREIS Jones

CYTHEREIS? ARDMORENSIS Harlton, n. sp.

Plate 33, figs. 14 *a–c*

Shell small, subovate, hinge line straight and about four-fifths as long as greatest length of carapace. Dorso-anterior angle gently rounded; dorso-posterior angle more or less rounded. Middle of dorsal margin very slightly curved. Anterior end of shell higher than posterior. A row of spines along front and back. Near the

dorso-posterior portion, about three-fourths of the length of the shell of each valve is an elevated wing, which diminishes gradually along the dorso-anterior portion. The carapace in the posterior view is triangular in shape, and its ends are rather thin and sharp. Surface smooth. The specimens of this species vary in size, the average dimensions being: length, 0.82 mm.; height, 0.33 mm.; greatest width, 0.52 mm.

Lower Glenn.—(Surface outcrop) NW. $\frac{1}{4}$ of NW. $\frac{1}{4}$ of NE. $\frac{1}{4}$ of Sec. 16 T. 6 S., R. 2 E., Love County, Oklahoma, about 8 miles south of Ardmore.

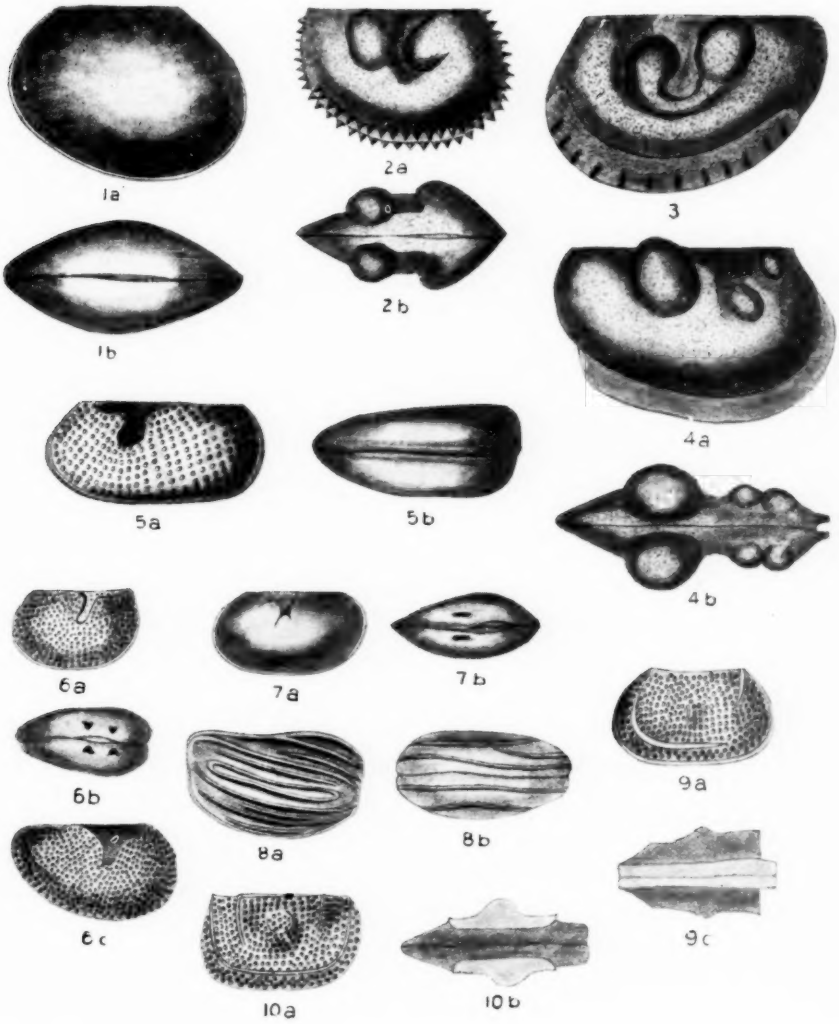
EXPLANATION OF PLATES

PLATE 32

FIGS. 1 *a, b.*—*Paraparchites inornata* (McCoy), ×30. *a*, lateral view of left valve; *b*, dorsal view.
2 *a, b.*—*Hollina grahamensis* Harlton, n. sp., ×30. *a*, lateral view of left valve; *b*, dorsal view.
3.—*H. granifera* (Ulrich), ×30. Lateral view of right valve.
4 *a, b.*—*H. tricollina* (Ulrich), ×30. *a*, lateral view of left valve; *b*, dorsal view.
5 *a, b.*—*Jonesina craterigera* (Jones and Kirkby), ×30. *a*, lateral view of right valve; *b*, ventral view.
6 *a–c.*—*J. arcuata* (Bean), ×30. *a*, lateral view of left valve; *b*, dorsal view; *c*, lateral view of left valve.
7 *a, b.*—*J. bradyana* (Jones and Kirkby), ×30. *a*, lateral view of right valve; *b*, dorsal view.
8 *a, b.*—*Glyptopleura costata* (McCoy), ×30. *a*, lateral view of left valve; *b*, edge view.
9 *a, b.*—*Amphissites dattonensis* Harlton, n. sp., ×30. *a*, lateral view of left valve; *b*, dorsal view.
10 *a, b.*—*A. centronata* (Ulrich and Bassler), ×30. *a*, lateral view of right valve; *b*, dorsal view.

PLATE 33

FIGS. 1 *a–c.*—*Healdia overbrookensis* Harlton, n. sp., ×30. *a*, lateral view of left valve; *b*, lateral view of right valve; *c*, dorsal view.
2 *a–c.*—*H. caneyensis* Harlton, n. sp., ×30. *a*, lateral view of left valve; *b*, posterior view; *c*, dorsal view.
3 *a–c.*—*H. oklahomaensis* Harlton, n. sp., ×30. *a*, lateral view of left valve; *b*, lateral view of right valve; *c*, dorsal view.
4 *a, b.*—*H. ciscoensis* Harlton, n. sp., ×30. *a*, lateral view of left valve; *b*, dorsal view.
5 *a, b.*—*H. boggyensis* Harlton, n. sp., ×30. *a* lateral view of left valve; *b*, dorsal view.
6 *a, b.*—*H. glennensis* Harlton, n. sp., ×30. *a*, lateral view of left valve; *b*, dorsal view.
7.—*Bairdia oklahomaensis* Harlton, n. sp., ×30. Lateral view of left valve.
8.—*B. ciscoensis* Harlton, n. sp., ×30. Lateral view of left valve.
9.—*B. texana* Harlton, n. sp., ×30. Lateral view of left valve.
10.—*B. glennensis* Harlton, n. sp., ×30. Lateral view of left valve.
11.—*B. subelongata* Jones and Kirkby, ×30. Lateral view of left valve.
12.—*B. hoxbarensis* Harlton, n. sp., ×30. Lateral view of left valve.
13 *a–d.*—*Cytherella incurvescens* Jones and Kirkby, ×30. *a, b*, lateral views of left valves; *c, d*, dorsal views.
14 *a–c.*—*Cythereis? ardmorensis* Harlton, n. sp., ×30. *a*, lateral view of left valve; *b*, anterior view; *c*, dorsal view.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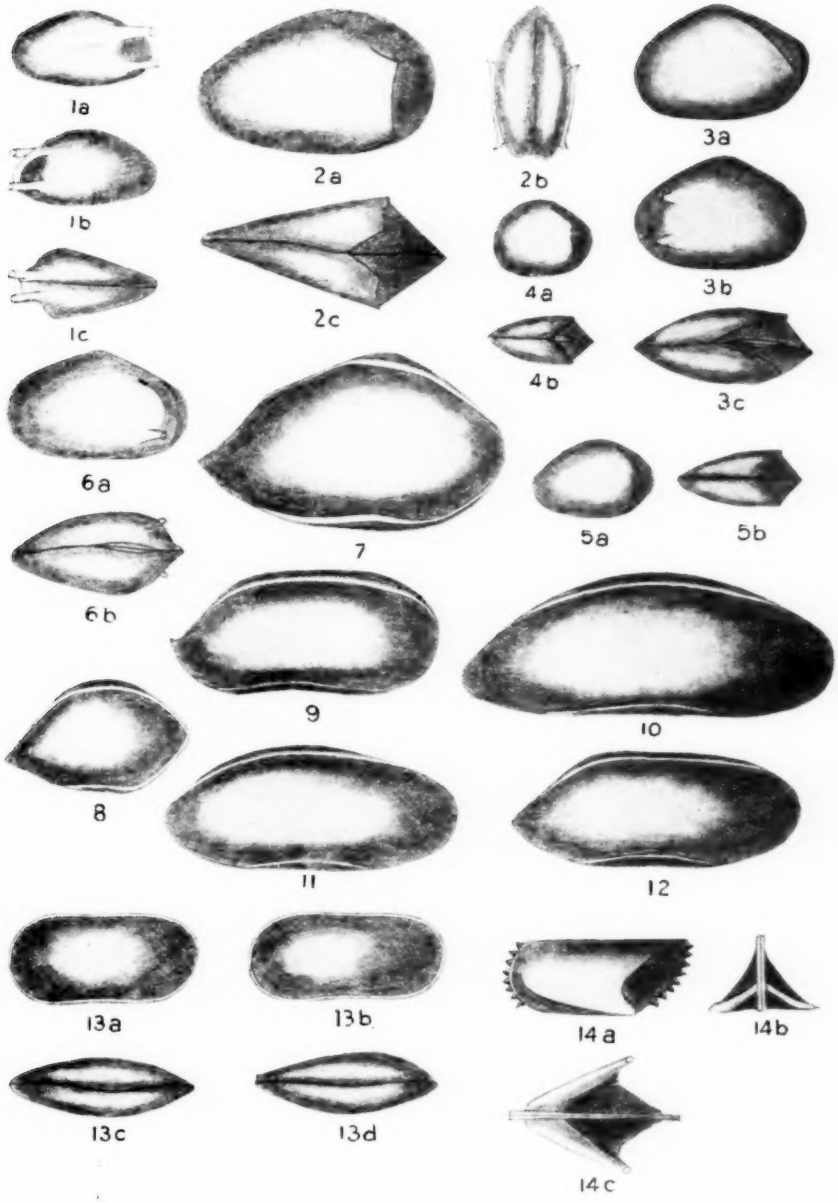
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THE AMERICAN CRETACEOUS FORAMINIFERA FIGURED BY EHRENBERG

JOSEPH A. CUSHMAN

ABSTRACT

Ehrenberg's plate 32 in the *Mikrogeologie* published in 1854 is entirely of figures of American Cretaceous Foraminifera. While many of these are evidently of the same species, workers on this formation should be familiar with this plate in Ehrenberg's rare work.

Much work is being done on the American Upper Cretaceous of our South and Southwest. In this work the earlier authors should be consulted, especially papers likely to have in them species allied to, or identical with, those of the American Cretaceous.

The European Upper Cretaceous foraminiferal fauna is at many localities very similar to that of our own. Many of the species of the two areas are identical. This is not always so apparent from a study of the literature as it is from a study of European material. Many of the earlier figures of Cretaceous Foraminifera, as well as those of other formations, are somewhat conventionalized or lacking in details so that it is necessary to have material from the type localities, or better still to study the original type specimens of the earlier authors. In this way the great similarity of the faunas and the large number of identical species is apparent.

One of the earliest authors to publish on American Cretaceous Foraminifera was Ehrenberg, who in his great work, the *Mikrogeologie* of 1854, devoted one plate entirely to American Cretaceous forms. This is plate 32 of that work. The plate is divided into two parts, the first part illustrating specimens from "Schreib-Kreide des Missouri-Gebietes," the second part from "Schreib-Kreide des Mississippi-Gebietes." No closer localities are given on the plates. Many of the species illustrated were described by Ehrenberg many years earlier, but they were not figured until this plate in the 1854 work. The specimens were mounted in balsam and figured as seen by transmitted light. A description of the Ehrenberg collection I have already given (Jour. Washington Acad. Sci., vol. 17, November, 1927, pp. 487–91).

This collection is preserved in Berlin, and the specimens are in excellent condition. As material is studied from the American Cretaceous, especially specimens studied in liquid by transmitted light, many of these early species of Ehrenberg can be identified. Their appearance in the dry state can then be recognized and a better knowledge of Ehrenberg's species thus be obtained. The rounded black spots on the specimens are air bubbles in the original specimens. I examined many of the twenty-five hundred or more original sheets of Ehrenberg's drawings and found

them as a rule very accurate indeed when compared with the original specimens, as I was able to do in Berlin through the courtesy of Dr. Pompecki and Dr. Dietrich.

The species which are chosen as the genotypes of a number of the genera of Ehrenberg I have already published.

Space will not be taken here to go into the details of the synonymy concerning each species, as this paper is merely intended to bring these figures before the American workers on this formation. The figures of three plates are copied from the large plate 32 of Ehrenberg. The explanation of plates gives the names as they appear on Ehrenberg's original explanation of plate 32.

A few notes on the genera may be given here for the sake of clearness for those who are not acquainted with the many names proposed by Ehrenberg. It will be seen by a study of the figures that most of them assigned to *Textilaria* belong under *Guembelina*. Our American Cretaceous Guembelinas should be studied in connection with this plate, as Ehrenberg has used many names under *Textilaria* which probably should be used for our American species.

The type of *Grammostomum* Ehrenberg is *G. tenue* Ehrenberg and, as already noted in the previous paper referred to, is a true *Bolivina*, and *Grammostomum* becomes a synonym of *Bolivina*. Ehrenberg referred many other things to *Grammostomum* later, but most of the American forms on these plates come under *Bolivina*.

Heterohelix Ehrenberg with its type *H. americana* figured on these plates must be used instead of *Spiroplecta* as it is an earlier name.

Phanerostomum Ehrenberg, 1841, had two species, neither of which were figured either then or since. According to the rules, one of these must be selected as the genotype. *P. integerrimum* Ehrenberg (Abhandl. Ak. K. Wiss., Berlin, 1841, p. 427) is here selected as the genotype.

The type specimen is Recent from off Vera Cruz, Mexico. I examined the specimen and the original drawing (unpublished) in Berlin, and it is to be referred to *Discorbis* Lamarck. The water-color drawing is brown, as so often occurs in *Discorbis*. *Phanerostomum ocellatum* Ehrenberg, also from Vera Cruz, is also a *Discorbis* and may be identical with *P. integerrimum*. Most of the forms of this plate placed by Ehrenberg under *Phanerostomum* are evidently *Globigerina* or *Globorotalia*.

The type of *Ptygostomum* Ehrenberg is *P. oligoporum* Ehrenberg and is probably a *Planorbulina*, but the species of plate 32 are evidently *Globigerina*.

Pleurites Ehrenberg as shown in the earlier paper is a synonym of *Bulimina* d'Orbigny.

The type of *Strophoconus* Ehrenberg is a *Virgulina*.

Sagrina longirostris is probably an *Eouvigerina*, although the apertural end only is figured.

Proroporus Ehrenberg is, from a study of the genotype, a direct synonym of *Bolivina* d'Orbigny; and *Loxostomum* must be used for those species with a terminal aperture.

Dimorpha saxipara has already become the genotype of *Bifarina*, but it is not the same as that genus, as ordinarily used.

Aspidospira saxipara is the common *Anomalina* of the American Cretaceous and is not well figured. The earlier chambers are not correct; and the inner chambers as shown cannot be seen in the original, which has the usual raised area about the center and spiral channel.

The other generic names used on the explanations of the plate will be understood.

The chief work to be done is to identify these species of Ehrenberg in our American Cretaceous material so far as is possible by transmitted light with specimens in liquid and then to check the surface characters so that they may be more adequately understood. The opportunity is thus offered of an interesting problem in clarifying the nomenclature in regard to these American Cretaceous forms.

Plate 34 contains the figures credited by Ehrenberg to the Cretaceous of the Missouri region, and is numbered to correspond with Ehrenberg's original figures on plate 32. Plates 35 and 36 contain the figures credited to the Cretaceous of the Mississippi region and are numbered to correspond to the second part of plate 32 so that reference may be easily made to Sherborn's Index or to other quotations from the original plate. The explanations are the same as used by Ehrenberg and may be checked with the notes already given.

EXPLANATION OF PLATES

PLATE 34

Figures after Ehrenberg's *Mikrogeologie*, pl. 32, pt. 1

SCHREIB-KREIDE DES MISSOURI-GEBIETES

FIG. 1.—*Miola? bursa* (*Vaginulina?*).
2.—*Nodosaria vulgaris.*
3.—*N. acus.*
4 *a.*—*Textilaria americana.*
4 *b.*—*T. striata.*
5.—*T. missouriensis.*
6.—*T. poroconus.*
7.—*T. americana? jung.*
8.—*T. globulosa.*
9.—*T. euryconus.*
10.—*T. gomphoconus.*
11.—*Grammostomum americanum.*
12.—*G. validum.*
13, 14.—*Spiroplecta americana* (*Heterohelix*, 1843).
15.—*Phanerostomum porulosum.*
16.—*P. dilatatum.*
17, 18.—*P. lacerum.*
19.—*P. laeve.*
20.—*P. quaternarium.*
21.—*Rotalia globulosa, protolepta.*

FIG. 22.—*Phanerostomum hispidulum.*
23.—*P. hexaleptum.*
24.—*P. asperum.*
25.—*P. senarium.*
26.—*Planulina globigerina.*
27.—*Ptygostomum senarium.*
28.—*P. quinarium.*
29.—*Phanerostomum hispidulum.*
30.—*P. dilatatum.*
31.—*P. hexacyclus.*
32.—*Rotalia lenticulina.*

PLATE 35

Figures after Ehrenberg's *Mikrogeologie*, pl. 32, pt. 2

SCHREIB-KREIDE DES MISSISSIPPI-GEBIETES

FIG. 1.—*Miliola striata.*
2 *a*.—*M. laevis.*
2 *b*.—*Ovulina clava.*
3.—*Dentalina americana.*
4.—*Nodosaria tumescens.*
5.—*N. vulgaris.*
6.—*N. ampla.*
7.—*Vaginulina calcipara.*
8.—*V. cretae.*
9.—*V. subacuta.*
10.—*Planularia elongata.*
11.—*Textilaria striata.*
12.—*T. globulosa.*
13.—*T. inflata.*
14.—*T. striata.*
15.—*Grammostomum americanum.*
16.—*G. phyllodes.*
17.—*G. invalidum.*
18.—*G. tessera.*
19.—*G. rhomboidale.*
20.—*Pleurites? americanus.*
21.—*Strophoconus spicula?*
22.—*Sagrina longirostris.*
23, 24.—*Proroporus obtusus.*

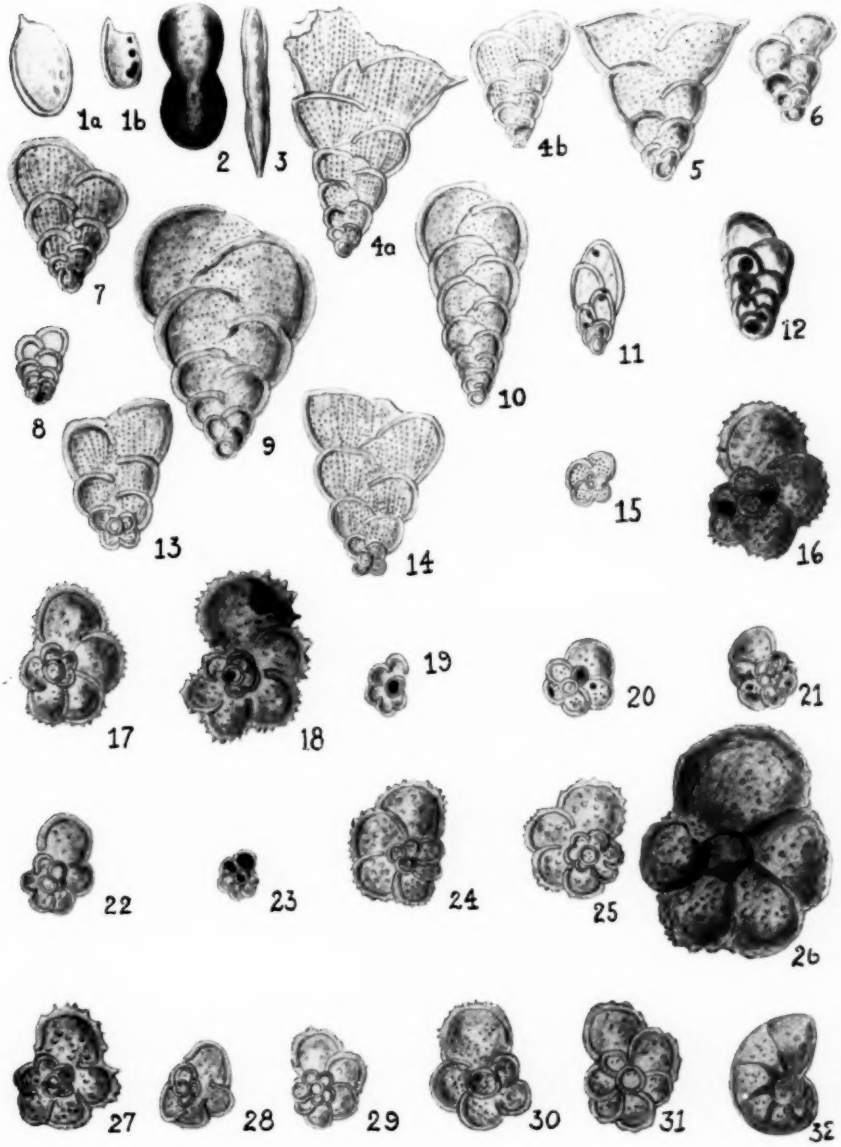
PLATE 36

Figures after Ehrenberg's *Mikrogeologie*, pl. 32, pt. 2

SCHREIB-KREIDE DES MISSISSIPPI-GEBIETES

FIG. 25.—*Spiroplecta americana* (*Heterohelix*, 1843)
26.—*S. rosula.*
27.—*Dimorphina saxipara.*
28.—*Guttulina turrita.*
29.—*Frondicularia? strophoconus.*
30.—*Rotalia senaria.*
31.—*R. globulosa, protolepta.*

FIG. 32.—*R. leptospira.*
33.—*R. calcipara.*
34.—*Omphalophacus? tenellus.*
35.—*Planulina nebulosa.*
36.—*Rotalia nonas?*
37.—*Cristellaria alta.*
38.—*Aspidospira saxipara.*
39.—*Robulina? denaria.*
40.—*Rotalia heptas.*
41.—*Planulina mississippica.*
42.—*Phanerostomum asperum.*
43.—*Planulina oligosticta.*
44.—*Phanerostomum globulosum.*
45.—*Rotalia globulosa, protolepta.*
46.—*Phanerostomum quaternarium.*
47.—*Robulina ocellus.*
48.—*Planulina suboctonaria.*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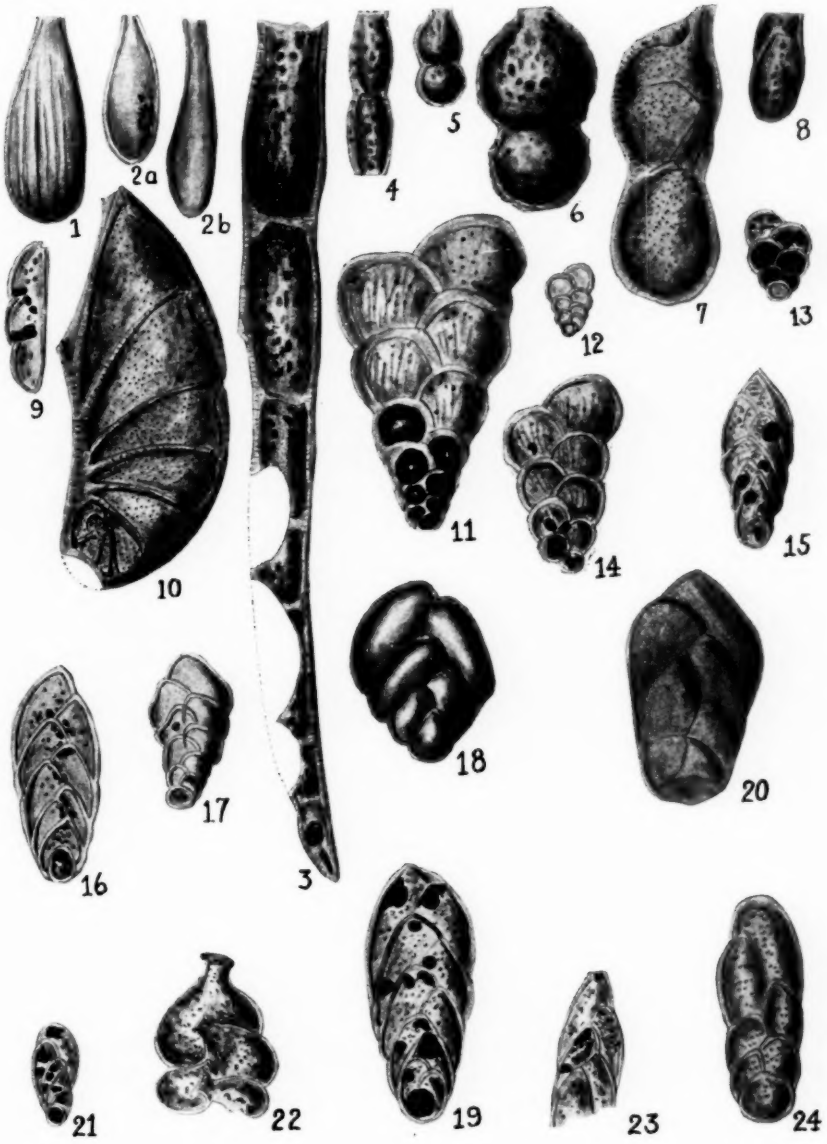
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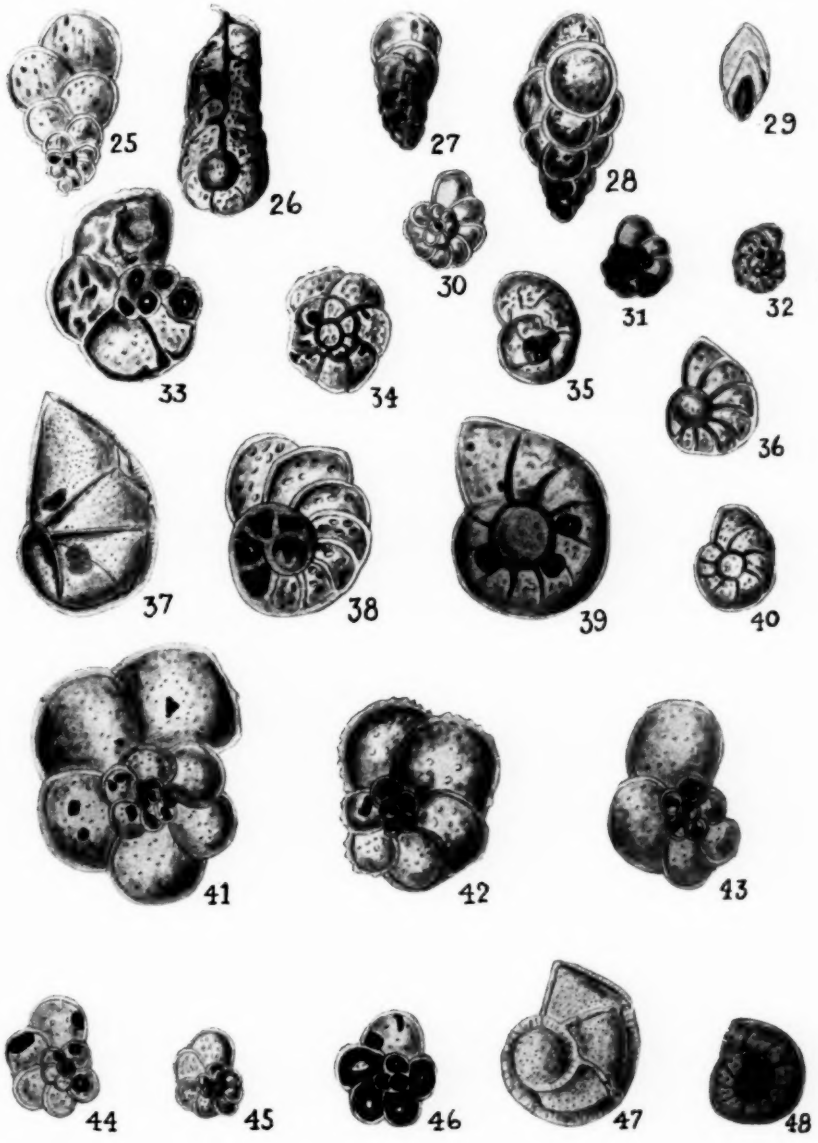
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A SIMPLE THIN-SECTION LAP[1]

MARCUS A. HANNA

The writer has been asked numerous times for a description of the lap he uses in making thin-sections. Some time ago he had a tracing made and several blue prints run off so as to make a description more adequate. Several have suggested that it might be well to reproduce the diagram in the *Journal of Paleontology* so that it would become more available for those desiring to make thin-sections, especially those engaged in sedimentology for the various oil companies. Although laps have been figured and described in numerous places, many if not most of the workers employed by oil companies do not have large reference libraries. It is for these reasons that the diagram is here reproduced. The writer wishes to state that he should receive no credit for the design of the apparatus, which, although simple, gives excellent results. The lap was designed and built by Mr. H. E. Minor of the Gulf Production Company several years before the writer became employed by that company. Only one addition has been made since, and that is the rubber belting extending around the inside. This is to prevent rock chunks from breaking loose from the glass when they have slipped from the fingers of the operator.

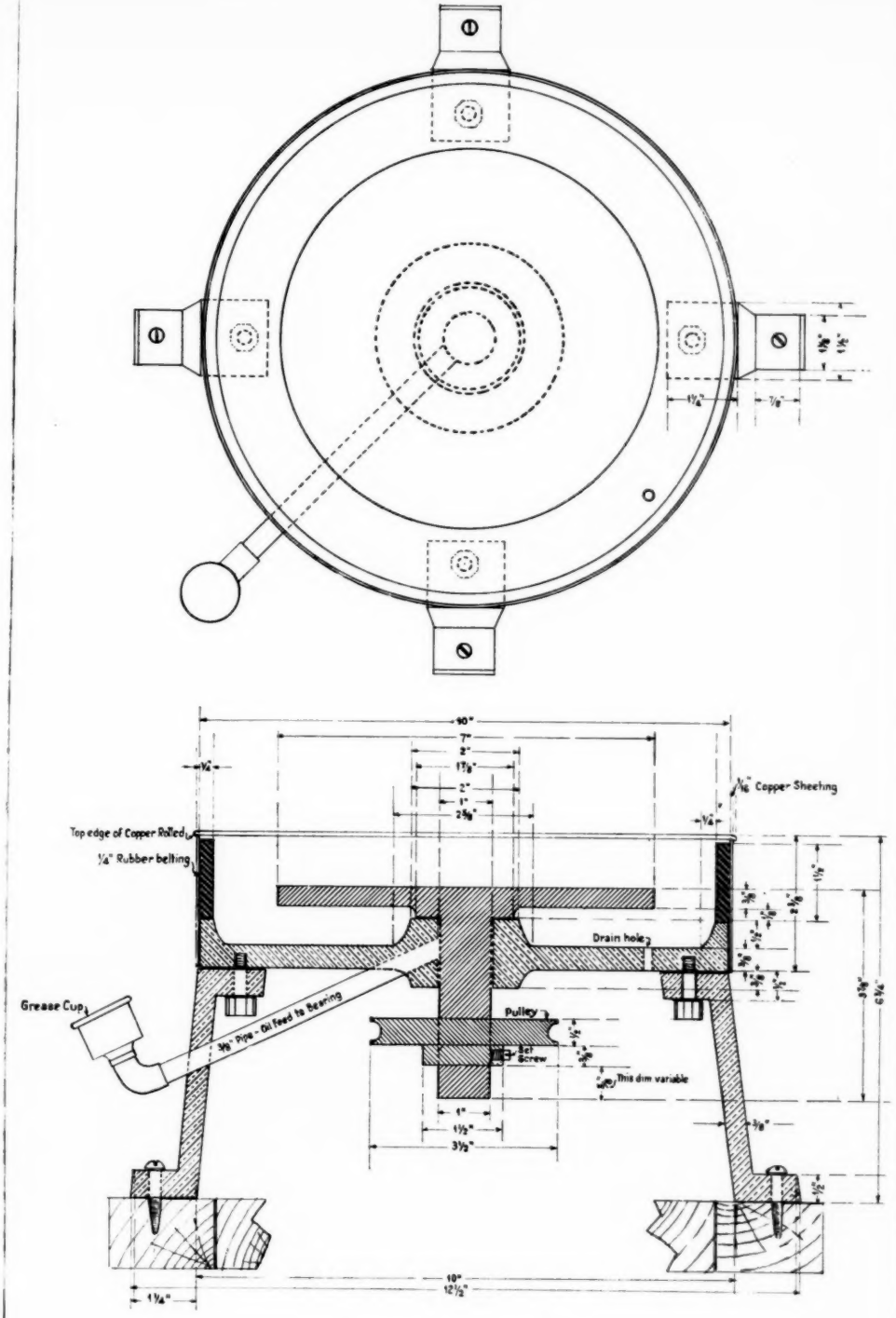
For power the writer uses a $\frac{1}{6}$ horse power, 1700 speed, Emerson motor, to which is attached a 2-inch pulley. The power is transmitted to the lap with a round sewing-machine belt. Fine emery is usually used on the lap, and is applied wet with a brush. Best results are obtained if the drain hole is kept open.

For a general discussion of preparation of thin-sections reference can be made to the recent paper by C. S. Ross, entitled, "Preparation of Sedimentary Materials for Study."[2]

HOUSTON, TEXAS
October 2, 1927

[1] Published with permission of the Gulf Production Company.

[2] C. S. Ross, *Econ. Geol.*, vol. 21, no. 5 (August, 1926), pp. 454–68.



THIN-SECTION & POLISHING APPARATUS
Designed by H.E.Minor 1914

THE FORAMINIFERA AND OSTRACODA OF THE MARINE YEGUA OF THE TYPE SECTIONS

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INTRODUCTION

The purpose of this paper is to describe and to discuss the foraminifer and ostracod microfauna of the Yegua beds of eastern Texas.

The materials studied were collected by Dr. Julia Gardner and Mr. Robert Lee Cannon in September, 1923 and 1924, along Elm Creek, a branch of Yegua Creek, Texas. The fossils come from the lower part of the Yegua, in the type sections of the formation.

ACKNOWLEDGMENTS

The writer is under obligation to Dr. Paul Bartch for the kind permission to carry on this work at the National Museum; to Dr. Julia Gardner for the opportunity to study and describe the Yegua microfaunas and for constant encouragement in the course of the work; to Dr. Joseph A. Cushman for help in the identification of the Foraminifera; to Dr. R. S. Bassler and Mr. P. V. Roundy for the use of their card catalogue of Ostracoda and for valuable suggestions; to Dr. W. P. Woodring, Dr. W. C. Mansfield, Dr. M. Goldman, and Dr. C. S. Ross for numerous courtesies, and to David White for helpful criticism in preparation of the paper; to Mrs. E. Bennett Decker and Miss Frances Wieser for preparation of plates.

GENERAL COMPOSITION OF THE FAUNAS

Of the twenty-four microfossils here described, twelve species are Foraminifera and twelve Ostracoda. All the shells are minute, the largest, those of *Bairdia oviformis*, being 1.3 mm. in length and 0.8 mm. in height or smaller. The others, exept *Cytheropteron virgineum*, which often is only slightly smaller than the *Bairdia*, range from half to the full size of the latter. The shells are usually well preserved, being translucent, porcelain-white, creamy-yellow, or brown, and commonly shiny.

The shells of most of the Ostracoda are ornate. Only three smooth species are found, viz., *Bairdia oviformis*, *Cytheropteron virgineum*, and *Cytherella texana*. *Ceratobulimina eximia*, which is a common Claiborne species of Texas, is the most abundant species in our Yegua collections, being present in all but one of the horizons examined by the writer. *Eponides patelliformis* is almost as common. The genus *Cristellaria* which is widely distributed in the Upper Cretaceous and in the Midway of Texas is represented here by only three species, and these are

extremely rare. *Polymorphina* and *Quinqueloculina* are represented each by three species those of *Polymorphina* being more abundant than the *Quinqueloculina*.

Of the Ostracoda the genus *Cythere* leads in number of species. *Cythereis* comes next: *Bairdia*, *Cytheridea*, *Cytheropteron*, and *Cytherella* are each represented by but one species; and those, except the *Bairdia*, are rather rare. *Bairdia oviformis*, on the other hand, is often very abundant. This is true especially at Evergreen Crossing, where the species is extremely common. *Cytheridea mülleri* is present in all the beds.

The fossiliferous bed at Evergreen Crossing is the richest of all in the number and variety of species in general and of Ostracoda in particular. It seems that conditions at this locality were very favorable for the growth of the Ostracoda and Foraminifera. At Price's Crossing the fauna is rather varied, but only four species occur in great numbers: *Ceratobulimina eximia*, *Eponides patelliformis*, *Eponides texana*, and *Bairdia oviformis*.

The characters of the sediments composing the six different fossiliferous horizons at Orell's Crossing are given on a later page in connection with the faunal lists. All the horizons have the same faunal contents, except the uppermost, No. 6, which has no Ostracoda or Foraminifera. This horizon carries more selenite than any other. The three lowest horizons, Nos. 1, 2, and 3, are much more fossiliferous than No. 5, which, at that, is richer than No. 4, for the latter is almost barren, being in this respect inferior only to horizon No. 6.

Habitat of the Fauna

Ceratobulimina eximia, the dominant species of the Yegua on Elm Creek, was first described by Rzehak from the Mellata marls in Lower Austria, which were deposited in the warm shallow sea of the Middle Oligocene. The other fossils here described point toward the following habitat features:

1. Strictly shallow warm sea species: *Bairdia oviformis* and *Polymorphina regularis*.

2. More or less shallow seas of temperate zones: *Cytheropteron virgineum* and *Cytheridea mülleri*.

3. Wide range in depth, from shallowest marine pools to great oceanic depth. Some at least of the forms may have been pelagic, sinking to the great depths at which they were collected.

The conclusion is reached that the Yegua beds on Elm Creek were laid down in shallow warm seas.

Correlations Indicated by the Microfauna

The described fauna strongly resembles the fauna of Moseleys Ferry, Cook Mountain formation, of Texas. Of the twenty-four species of Ostracoda and Foraminifera of the Yegua, the seventeen following species are found in the Cook Mountain beds:

Quinqueloculina seminulum (Linné)
Q. vulgaris d'Orbigny
Q. claiborniana, sp. nov.
Cristellaria rotulata (Lamarck)
Polymorphina gibba d'Orbigny
P. problema d'Orbigny
P. regularis Münster
Eponides patelliformis, sp. nov.
E. texana, sp. nov.
Ceratobulimina eximia (Rzehak)
Bairdia oviformis Speyer
Cythere leeana, sp. nov.
C. texana, sp. nov.
Cytheridea mülleri (Münster)
Cythereis bursilloides, sp. nov.
Cytheropteron virgineum Jones
Cytherella texana, sp. nov.

The microfauna of the Yegua along Elm Creek finds its closest relationship with the microfauna of the Cook Mountain formation, and is evidently most intimately bound to that fauna.

In fact the Yegua microfauna examined from Lee County is so far identical with that in beds classed as Cook Mountain at Moseley's Ferry, Brazos River, Robertson County; Smithville, Bastrop County; and along San Antonio River, 4 miles south-southeast of Floresville, Wilson County, that it would seem that the beds carrying this fauna in the two regions must be nearly contemporaneous.

Description of Sediments and Local Faunal Lists

I. Section at Orell's Crossing, Elm Creek, 5.2 miles northwest of Giddings, Lee County, Texas

Total thickness, 31 feet, 6 inches.

Horizon No. 6 (beginning at the top)

Laminated sands and clays, gray, greenish gray; darker toward the base and lighter toward the top; containing a very large amount of glauconite[g][1] pallets, selenite, and some plant remains; microfossils wholly lacking. Thickness, 15 feet.

Horizon No. 5

Brownish gray, soft, finely stratified and ferruginous clays, with a little dark-blue shale and light-blue sands. Clays wholly lacking in microfauna. Sands carry some microfossils. Selenite present but in much lesser quantity than in No. 6. Thickness, 6 feet.

Fauna:

[1] Determined by Dr. C. S. Ross, of the U. S. Geological Survey.

Cristellaria rotulata E. R.
Eponides patelliformis V. R.
Ceratobulimina eximia C.
Cythere leeana R.
Cythere texana R.

Horizon No. 4

Dark-blue-gray to black clays, with pockets of sand and a large amount (almost as large as in No. 6) of selenite, mica, and glauconitic pallets; poor in micro-fossils. Thickness, 5 feet.

Fauna:

Eponides patelliformis R.
Ceratobulimina eximia R.

Horizon No. 3

Clays with abundant well-cemented, brown, ferruginous concretions and rich in glauconite; rather rich in microfossils. Thickness, 2 feet.

Fauna:

Quinqueloculina seminulum R.
Q. vulgaris R.
Polymorphina gibba R.
P. problema R.
Eponides patelliformis E. C.
E. texana R.
Ceratobulimina eximia E. C.
Cythere claiborniana V. R.
C. texana R.
Cytheridea mülleri R.
Cythereis davidwhitei E. R.
Cytherella texana V. R.

Horizon No. 2

Brown to yellow clays and ferruginous sands containing a large amount of selenite and rich in microfossils. Thickness, 2 feet, 6 inches.

Fauna:

Quinqueloculina seminulum E. R.
Q. vulgaris V. R.
Cristellaria rotulata E. R.
Polymorphina gibba R.
P. problema R.
Eponides patelliformis E. C.
E. texana R.
Ceratobulimina eximia E. C.
Cythere texana R.
Cytheridea mülleri C.

Cythereis davidwhitei E. R.
Cytherella texana V. R.

Horizon No. 1

Dark clays with sandy pockets; some selenite and glauconite; rich in fossils. Thickness, 1 foot.

Fauna:

Polymorphina problema R.
Eponides patelliformis V. C.
Ceratobulimina eximia V. C.
Bairdia oviformis C.
Cythere texana R.
Cytheridea mülleri R.
Cythereis bursilloides R.
C. davidwhitei E. R.
Cytheropteron virgineum V. R.

II. Horizon at Evergreen Crossing, Elm Creek, 5 miles north of Giddings, Lee County, Texas, bed No. 5 of Dumble section

Blue gypsiferous clays, with ferruginous concretions and lignitic clays; chocolate brown to black, with mica, pyrite, and a large amount of dark-brown, elongated pellets of glauconite, and some plant remains; very fossiliferous. Exposed thickness, 6 feet.

Fauna:

Quinqueloculina seminulum C.
Q. vulgaris V. C.
Q. claiborniana V. C.
Cristellaria rotulata R.
C. torrida E. R.
C. orelliana C.
Polymorphina gibba V. C.
P. problema C.
P. regularis R.
Eponides patelliformis V. C.
E. texana C.
Ceratobulimina eximia E. C.
Bairdia oviformis V. C.
Cythere claiborniana C.
C. evergreenica R.
C. leeana V. C.
C. orelliana R.
C. texana C.
Cytheridea mülleri C.
Cythereis bursilloides E. C.

C. davidwhitei E. R.
Cytheropteron virgineum C.
Cytherella texana E. R.

III. Horizon at Price's Crossing, Elm Creek, Lee County, Texas

A thin outcrop of finely stratified blue and brown clays; weathering to a yellowish brown; contains selenite and some glauconite pellets; very fossiliferous.

Fauna:

Cristellaria rotulata R.
C. orelliana V. R.
Polymorphina gibba V. R.
P. problema R.
Eponides patelliformis E. C.
E. texana V. C.
Ceratobulimina eximia E. C.
Bairdia oviformis V. C.
Cythere texana R.
Cytheridea mülleri V. R.
Cythereis davidwhitei V. R.
Cytheropteron virgineum R.
Cytherella texana R.

In the list E. R. = extremely rare, V. R. = very rare, R. = rare, C. = common, V. C. = very common, E. C. = extremely common.

Description of the species

Subkingdom PROTOZOA

Order FORAMINIFERA (RETICULARIA)

Family MILIOLIDAE

Subfamily MILIOLININAE

Genus QUINQUELOCULINA d'Orbigny, 1826

QUINQUELOCULINA SEMINULUM (Linné)[1]

Plate 38, fig. 28

"Conchula arcte in contorta, etc.," Plancus, De Conch., min. not., 1739, p. 19, pl. 2, figs. 1 *a, b, c.*

Serpula seminulum Linné, Sept. 12th ed., No. 791, 1767, p. 1264.

Quinqueloculina seminulum d'Orbigny, Ann. Sci. Nat., vol. 7, no. 44, 1826, fig. 303.—Jones, Parker, and H. B. Brady, Foram. Crag. Paleograph. Soc. Mon., 1866, pp. 9, 116, pl. 3, figs. 35–36.—Goes, Kongl. Svenska Vetenskaps-Akad., Handlinger, vol. 10, no. 4, 1882, pp. 122–23, pls. 11–12.—H. B. Brady, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884,

All specimens described or figured are the property of the U. S. National Museum.

p. 157, pl. 5, figs. 6 *a*, *b*, *c*.—Goes, kongl. Svenska Vetenskaps-Akad., Handlinger., vol. 24, 1894, pp. 108–12.—Flint, Rep. Rec. For. U. S. Nat. Mus., 1897 (1899), p. 44, pl. 2, fig. 2, *Miliolina seminulum* WILLIAMSON, Rec. For. Gr. Br., 1858, p. 85, pl. 7, figs. 183–85.

Test oblong, smooth, slightly compressed, with rounded peripheral margin; chambers ventricose, four partially visible on one side and three on the other; aperture slightly produced, fairly large and rounded with a simple tooth which is cleft at the free end; sutures distinct; proportion between length and width approximately as 7:4; color porcelain-white to yellow-brown.

Quinqueloculina seminulum is a very common species of the modern seas. It is living in the Arctic and the Antarctic as well as at the Equator. It ranges from the shallowest pools to a depth of 3,000 fathoms.

Fossil *Quinqueloculina seminulum* is recorded from the Lower Eocene and upward in the geological column. It is found at Moseley's Ferry, Robertson County, Cook Mountain formation, Eocene, of Texas; in the Byram Marl, Upper Oligocene, of Mississippi (Cushman); in the St. Mary formation, and at Jones's Wharf, and Governor Run, Choptank formation, Miocene, of Maryland (Bagg); near Suffolk, Miocene, of Virginia (Cushman); in the Caloosahatchie, and Shell Creek, Desoto County, Pliocene, of Florida (Cushman); at Muldrow's Mill, Miocene, and Waccamaw River, Pliocene, both of South Carolina (Cushman); 1.16 miles west of Wilmington, Pliocene, North Carolina (Cushman); in the London Clays, Lower Eocene, of England (Brady); in the Grignon beds of the Paris Basin, Eocene, of France (Brady); in the Red Crag, Middle Pliocene, of England (Jones, Parker, Brady); in the Gedgrave and Sudbourne, Upper Pliocene, of England (Jones, Parker, and Brady).

Varieties of *Quinqueloculina seminulum* are found in the Cretaceous deposits of Europe and America.

Locality: Evergreen Crossing, rare. Orell's Crossing, rare. Both localities in Lee County, Texas.

QUINQUELOCULINA VULGARIS d'Orbigny

Plate 38, figs. 25–27

Quinqueloculina vulgaris D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, no. 33, p. 302.—TERQUEM, Mèm. Soc. Géol. France, ser. 3, vol. 6, 1878, p. 60, pl. 6, figs. 20–21.—SCHLUMBERGER Mèm. Soc. Géol. France, vol. 6, 1893, pp. 65–66, text figs. 13–14, pl. 2, figs. 65–66.—CUSHMAN, U. S. Nat. Mus. Bull. 71, pt. 6, 1916, p. 46, pl. 2, fig. 3.

Test smooth, biconvex, orbicular, small and stout, proportion between length and width approximately 5:4; periphery bluntly angular; chambers few, triangular; sutures well marked; inner wall thick; aperture long and narrow, divided by a simple forking tooth; color yellow, brown, or white.

Quinqueloculina vulgaris is one of the most common species of this genus in the North Pacific. It is found around the Hawaiian Islands, near the Midway Islands; near Japan, and in the Gulf of Marseilles, France.

Quinqueloculina vulgaris is recorded from the Cook Mountain formation of Texas.

Locality: Evergreen Crossing and Orell's Crossing, Lee County, Texas. Very common.

QUINQUELOCULINA CLAIBORNIANA, sp. nov.

Plate 38, figs. 23, 24

Test small, smooth; proportion between length and width approximately 2:1; chambers ventricose, three partially visible on one side and three on the other; sutures distinct, unequally curving, one of them forming almost a triangular curve; peripheral margin irregularly subcarinate; final chamber projecting beyond the base of the penultimate; aperture fairly large and rounded; color porcelain-white.

Quinqueloculina claiborniana was found by the writer at Moseley's Ferry, Robertson County, Cook Mountain formation, of Texas.

Locality: Evergreen Crossing, Lee County, Texas. Rare.

Family LAGENIDAE

Subfamily NODOSARIINAE

Genus CRISTELLARIA Lamarck, 1812

CRISTELLARIA ROTULATA (Lamarck)

Plate 38, figs. 12, 13, 29

"Cornu Hammonis seu Nautili," PLANCUS, Conch. min., 1739, p. 13, pl. 1, fig. 3.
Lenticulites rotulata LAMARCK, Ann. du Mus., vol. 5, 1804, p. 188, no. 3.
Cristellaria calcar (typica) WILLIAMSON, Rec. For. Gr. Br., 1858, p. 27, pl. 2, figs. 52, 53.
Cristellaria rotulata PARKER and JONES, Phil. Trans., vol. 155, 1865, p. 345, pl. 13, fig. 19.—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, 1884, p. 547, pl. 69, figs. 13*a–b*.—FLINT, Rep. U. S. Nat. Mus., 1897 (1899), p. 317, pl. 64, fig. 4.—BAGG, U. S. G. S. Bull. 513, 1912, p. 67, pl. 19, figs. 5*a*, *b*.—CUSHMAN, U. S. Nat. Mus. Bull. 104, pt. 4, 1923, p. 108, pl. 22, fig. 2; pl. 28, figs. 1, 2.—CHAPMAN and PARR, Jour. Linnean Soc., vol. 36, no. 245, 1926, p. 373, pl. 21, fig. 67.

Test smooth, lenticular, biconvex, involute, strongly built; peripheral margin sharp, not carinate; last-formed spiral consisting of nine chambers, overlapping and separated from each other by sutures, which are usually distinct, straight, limbate toward the periphery and reaching only to the umbilicus; umbilicus large, raised, and filled with a clear shell-substance; aperture large, radiate, placed at the peripheral angle of the last chamber; color yellow, porcelain-white, or brown.

Cristellaria rotulata is one of the most widely distributed species of the living Foraminifera. It is found from the Arctic Circle to Patagonia, and in waters only a few fathoms deep to 2,000 and more (Brady).

Fossils of this species are recorded from the Upper Trias of Derbyshire; Lower, Middle, and Upper Lias of England (Jones, Parker, Brady, Blake); the Cretaceous formations of England, Ireland, and Germany, and in almost any microzoic deposits of the Tertiary (Brady, Sowerby, Jones, and Wright). It is a common

species in the Upper Cretaceous and Tertiary of Texas. It is found in the Tertiary of Victoria, Australia, at Grice's Creek, where it is frequent; at Balcombe Bay, where it is very rare (Chapman and Parr); and in Kackeraboite Creek, where it is very rare. It is found in the Taylor marl, Berry's Crossing on Onion Creek, Upper Cretaceous, of Texas (Carsey); in the greensands of New Jersey (Bagg, Clark); in the Marianna limestone, and in the Mint Spring marl, at Mint Spring, and in the Red Bluff clay, at Hiwanee Oligocene, of Mississippi (Cushman); in the Aquia formation at Upper Marlboro, 1 mile southeast of Mason Springs, Eocene of Maryland (Bagg); in the Talbot formation, Wailes Bluff, near Cornfield Harbor, Saint Mary's County, Pleistocene, of Maryland (Clark); in the Miocene and Pliocene of southern California (Bagg); in the Cook Mountain formation, Eocene, of Texas; at Biarritz, Le Côte des Basques, Eocene of France (Halkyard).

Locality; Orell's Crossing, very rare. Evergreen Crossing, rare.

CRISTELLARIA TORRIDA Cushman

Plate 38, fig. 15

Cristellaria torrida CUSHMAN, U. S. Nat. Mus. Bull. 104, pt. 4, 1923, p. 105, pl. 25, fig. 1.

Test minute, smooth, translucent, biconvex, close-coiled, slightly compressed; peripheral margin sharp, with a thin translucent keel; last convolution consisting of six chambers, separated from one another by distinctly marked lines of a clear shell-substance; sutures, radiating from the umbilicus, failing to reach the center of the shell; umbilicus large, filled with clear shell substance; edge nearest to the umbilicus almost straight, slightly concave for two-thirds of the distance between the base of the last-formed chamber and the peripheral margin; aperture placed near the margin, simple, radiate; color yellow-brown, shiny.

The specimen in hand is much smaller than that described by Dr. Cushman. It may be a young shell, otherwise it closely resembles Dr. Cushman's species.

Cristellaria torrida is found recent in the northern part of the Gulf of Mexico; on the southern coast of Florida; and near Cape Hatteras on the Atlantic Coast (Cushman).

Locality: Orell's Crossing. Extremely rare.

CRISTELLARIA ORELLIANA, sp. nov.

Plate 38, fig. 14

Test minute, biconvex, involute, glistening; periphery sharp, almost straight in the first quarter of the circumference that lies above the umbilicus, forming a sharp angle at the point where the first quarter of the periphery ends and the second begins, beyond which point it forms a gently curving keel transparent and rather broad, which gradually becomes narrow and opaque and ends at the base of the septal face; chambers few (seven to eight), unequal, crescentic or sectorlike in form; sutures, running from the umbilicus, distinct, oblique, slightly raised, filled with a clear shell-substance; umbilicus very large, smooth, slightly raised and filled with translucent shell-substance; aperture elongate, simply truncate,

placed near the periphery, at the top of last-formed chamber; color light-brown; keel colorless where transparent, light yellow where translucent.

Locality: Orell's Crossing, Evergreen Crossing, and Price's Crossing, Lee County, Texas. Extremely rare.

Family POLYMORPHINIDAE

Subfamily POLYMORPHININAE

Genus POLYMORPHINA d'Orbigny, 1826

POLYMORPHINA GIBBA d'Orbigny

Plate 38, figs. 20–22

Polymorphina subcordiformis vel. *"oviformia,"* SOLDANI, Testaceographia, vol. 1, pt. 2, 1791, p. 114, pl. 113, figs. *z, zz.*—*Polymorphina (Globulina) gibba* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 266, no. 20, Modèle no. 63.—JONES, PARKER and H. B. BRADY, Mon. Foram. Crag, pt. 3, 1896, p. 255.—H. B. BRADY, Rep. Voy. *Challenger*, Zoöl., vol. 9, p. 568, pl. 71, figs. 12 *a–b.*—CHAPMAN and PARR, Jour. Linnean Soc., vol. 36, 1926, p. 373, pl. 21, fig. 67.

Test usually spherical, sometimes oval, rounded at the base, becoming more slender toward the anterior end; chambers few, usually only three visible, compact and overlapping; sutures marked by fine lines, sometimes so delicate as hardly to be distinguished; aperture flush with the body in all specimens examined, but this very common species presents considerable variation in the shape of the aperture, which may be acuminate, truncate, placed on a mammillate protuberance, or, in very rare cases, inverted so as to form an entosolen; color porcelain-white to yellow-brown, predominantly yellow-brown.

Polymorphina gibba is a cosmopolitan living species of wide bathymetrical range, but it is most common in comparatively shallow waters of the temperate zones. It is found in fossiliferous deposits from the Jurassic to the present day. It is common in the Cretaceous and Tertiary of Europe (Jones, Chapman). It is recorded from the Upper Cretaceous of Texas and the New Jersey greensand (Bagg); from the Midway, basal Eocene, and from Moseley's Ferry, Robertson County, Cook Mountain formation, Eocene, of Texas; from the Aquia formation, Upper Marlboro, Brooks Estate near Seat Pleasant, and from the Calvert formation, Chesapeake Beach, of Maryland (Bagg); from the Byram marl, Byram, from the Mint Spring marl, Mint Spring Bayou, Vicksburg, and from the Marianna limestone, Oligocene, of Mississippi; from the Glendon limestone, Oligocene, of Mississippi (Cushman); from Maysville, Miocene, of South Carolina (Cushman); from Shell Creek, Desoto County, Pliocene, of Florida (Cushman); from the Pliocene and Pleistocene, of southern California (Bagg); from Muddy Creek (lower bed), Oligocene, and from the Eocene of Victoria, Australia (Chapman and Parr).

Locality: Evergreen Crossing, very common. Orell's Crossing, rare. Price's Crossing, very rare.

POLYMORPHINA PROBLEMA d'Orbigny, 1826

Plate 38, figs. 16, 17

Polymorphina (*Guttulina*) *problema* D'ORBIGNY, Ann. Sci. Nat., vol. 7, 1826, p. 266, 1826, no. 14, Modele no. 61.—EGGER, Neues Jahrb., 1857, p. 287, pl. 10, figs. 23–25.—JONES, PARKER and H. B. BRADY, Mon. Foram. of Crag, Palaeograph. Soc., pt. 3, 1896, p. 267, pl. 1, fig. 64; pl. 5, fig. 23; pl. 6, figs. 2 *a–b*.—Cushman, U. S. Nat. Mus. Bull. 104, pt. 4, 1923, p. 152.

Guttulina problema D'ORBIGNY, For Foss, Vienna, 1846, p. 224, pl. 12, figs. 23–25.

Test smooth, spherical or ovate, sometimes decidedly oblong (specimens from the Crag, Pliocene, England), greatest width a little above the middle of the test; basal end rounded, anterior end obtuse; aperture simple, radiate; chambers numerous, much inflated, obliquely overlapping one another, grouped usually irregularly, sometimes triserially; sutures deep; color percelain-white to yellow-brown.

Polymorphina problema is distinguished from *Polymorphina communis* d'Orbigny by the obtuse anterior end, *P. communis* having an acuminate end.

Among living species *P. problema* is a very common inhabitant of shallow seas and has a very great geographical range.

The species has been found in the Lower Lias, of England (Jones); in the Bargate beds, Neocomian, of Surrey, England (Jones); in the Gault, Lower Cretaceous, of Folkstone, England (Jones); in the Red Chalk, Upper Cretaceous, of England (Jones); in the Oligocene of Alsace and Pietzpuhl (Jones, Parker); in the Miocene, of Vienna, and Muddy Creek, Victoria, Australia (Chapman and Parr); in the Pliocene of Antwerp, Belgium (Jones); in the Garrusha, Pliocene, of Spain (Jones); in the St. Erth and Coralline Crag, Lower Pliocene, of England (Jones); in the Cook Mountain formation, Eocene, of Texas; in the Byram marl at Byram, and in the Marianna limestone, in the Bed Bluff clay, and in the Glendon limestone, Oligocene, of Mississippi (Cushman).

Locality: Orell's Crossing and Price's Crossing, rare. Evergreen Crossing, common.

POLYMORPHINA REGULARIS von Münster

Plate 38, figs. 18, 19

Polymorphina regularis VON MÜNSTER, in Römer, Neues Jahrb., 1838, p. 385, pl. 3, fig. 21.—REUSS, Sitz. k. k. Ak. Wiss. Wien, vol. 18, 1856, p. 247, pl. 7, figs. 70–73.—JONES, Mon. Foram. of Crag, Palaeograph. Soc., pt. 4, no. 293, 1897, p. 386.

Test smooth, strongly compressed, irregularly rhomboidal (sometimes lanceolate or almost triangular, ovate or elliptical), unequilateral; sides separated by a rather broad, very blunt longitudinal ridge; compression of the test greatest on either side of the ridge, the maximum width being a little above the middle; basal end narrow, bluntly rounded; anterior end tapering; aperture rounded; chambers numerous, from 5 to 9 on each side, slightly convex, oblique; sutures shallow, deepening sometimes toward the periphery and cutting the margin; periphery slightly bent in; color white, yellow, or brown.

Fossil specimens of *Polymorphina regularis* are recorded from the "Sternberger Kuchen," Upper Oligocene, of Mecklenburg, Germany (Münster, Reuss); from the sands of the Cassel, Upper Oligocene, of Westfalia, Germany (Münster, Reuss); from the Coralline Crag and Upper Crag, Lower and Upper Pliocene, of England (R. Jones); from the Cook Mountain formation, Eocene, of Texas.

Locality: Orell's Crossing and Evergreen Crossing. Rare.

Family ROTALIIDAE

Subfamily ROTALIINEA

Genus EPONIDES Monfort, 1808

EPONIDES PATELLIFORMIS, sp. nov.

Plate 38, figs. 6–8

Test irregularly biconvex; superior side conical, inferior side very slightly convex, very much flattened, particularly toward the margin; test composed of three and a half convolutions, of which the outermost has from nine to thirteen chambers; chambers numerous, nearly equal, separated by sutures; sutures distinct, oblique on the superior side, but on the inferior side radiate, slightly depressed, becoming more so toward the periphery, where oval depressions are formed, sometimes hardly seen; toward the umbilicus, on the inferior side, the sutures are raised into tubercules; which form a ring around the umbilicus; umbilicus slightly depressed, partly filled with a clear shell-substance; peripheral outline irregularly spherical, sharp, keeled; keel very narrow, made of a clear shell-substance; perforations numerous and minute; aperture elongated, placed on the inferior side of the last-formed chamber between the periphery and the umbilicus, but not reaching the keel; colorless to yellow-brown; translucent.

Viewed from the slightly convex and much flatter inferior side, with its radiating sutures, its ring of tubercules around the somewhat depressed umbilicus, and its irregularly circular peripheral margin, this test suggests a simple-rayed flower of the field daisy type. It is somewhat like *Eponides mexicana* Cushman (*Pulvinulina mexicana* Cushman), but it may be easily distinguished from the latter by its much less convex and much flatter inferior surface and by the greater number of convolutions and chambers.

Eponides patelliformis is found in the Cook Mountain formation, Eocene, of Texas.

Locality: Orell's Crossing and Evergreen Crossing, very common. Price's Crossing, extremely common.

EPONIDES TEXANA, sp. nov.

Plate 38, figs. 1–5

Test small, spherical, trochoid, biconvex, dull or shiny; inferior side forming a low cone; superior side very slightly convex, much flattened, particularly toward

the periphery; periphery distinct, keeled; keel very thin, irregular, broad to narrow, serrate, transparent or translucent; test composed of three convolutions, the outermost of eight chambers; chambers not always easy to distinguish, irregular in form, those on the superior side usually crescentic, those on the inferior side raylike; sutures not always distinct, often rather broad, and filled with a clear shell-matter; umbilici filled, the superior being so transparent that the proloculum may be faintly seen; surface sometimes smooth, often rough, especially on the inferior side; pores fine or sometimes coarse; aperture low, placed on the inferior side between the umbilicus and the periphery; color mostly brown, sometimes yellow or creamy.

Eponides texana is found in the Cook Mountain formation, Eocene, of Texas.

Locality: Orell's Crossing and Evergreen Crossing, common. Price's Crossing, very common.

Family CASSIDULINIDAE

Subfamily CERAROBULIMININEA

Genus CERATOBULIMINA Toula, 1920

CERATOBULIMINA EXIMIA (Rzehak)

Plate 38, figs. 9–11

Pulvinulina eximia RZEHAK, Annal. k. k. Naturhist. Hofmuseum, vol. 3, 1888, p. 263, pl. 2, figs. 7 *a–c*.

Test spherical, biconvex, somewhat depressed, very smooth, finely porous, comprising two and one-half convolutions, the last of which is composed of from eight to nine chambers; chambers numerous, rather flat, separated from each other by sutures, unequal, the last-formed chambers being considerably larger; sutures shallow, angular, becoming almost straight or radiate near the umbilicus; umbilicus depressed; peripheral margin bluntly rounded; aperture elongated, springing from the umbilicus on the inferior side and extending to the superior side, cleft and concealed by the last chamber; color porcelain-white, creamy, or brown.

Ceratobulimina eximia was described by Rzehak under the genus *Pulvinulina* prior to the differentiation of *Ceratobulimina* by Toula in 1920. It belongs to the latter genus.

Ceratobulimina eximia has been found in the Meletta marls, of the Middle Oligocene, in Lower Austria (Rzehak), and in the Claiborne formation, Eocene, of Texas, where this species is abundant.

Locality: Orell's Crossing, Evergreen Crossing, and Price's Crossing. Extremely common.

ARTHROPODA

Class CRUSTACEA

Superorder OSTRACODA

Family CYPRIDAE

Genus BAIRDIA M'Coy, 1844

BAIRDIA OVIFORMIS Speyer

Plate 39, figs. 1–3

Bairdia oviformis SPEYER, Die Ostrac. der Casseler Tertiarbildungen, 1863, p. 44, pl. 1, fig. 6. —G. S. BRADY, Trans. Zoöl. Soc., vol. 10, 1878, p. 383, pl. 63, figs. 7 *a–c*.

Shell medium sized, smooth, glossy or dull, strongly convex, broad, subtriangular to elliptical; valves unequal, left valve larger and overlapping the much smaller right valve; overlap greatest along the dorsal margin and at the middle of the ventral edge, very slight at the anterior and the posterior extremities; dorsal margin arched strongly; ventral margin of right valve slightly convex, almost straight; anterior end of left valve broadly rounded at the center, obliquely rounded toward the dorsal and ventral margins; anterior end of right valve narrower, acutely rounded; posterior end of left valve sharply rounded; posterior end of right valve triangularly beaked; proportion between length and height 3:2; greatest height at the center; hinge-line simple; inner side of posterior, anterior, and ventral margin of the valves provided with narrow lamellae; color porcelain-white, creamy, or yellow.

Bairdia oviformis is an extinct species. It has been found in the *Isocardia cor* bed of the "Sables moyens" Antwerp Crag, Pliocene, of Belgium (C. S. Brady); in the Cassel beds, Westfalia, Upper Oligocene, of Germany (Speyer); in the Cook Mountain formation, Eocene, of Texas.

Locality: Orell's Crossing, common. Price's Crossing, very common. Evergreen Crossing, extremely common.

Family CYTHERIDAE

Genus CYTHERE Müller, 1785

CYTHERE CLAIBORNIANA, sp. nov.

Plate 39, fig. 19

Shell minute, delicate, elongate-ovate, biconvex, greatest convexity toward the posterior extremity, transparent and ornate; valves of the same shape and equal, except for the slight overlap of the right valve by the left along the upper portion of the extremities; proportion between length and height 5:2; the greatest height being near the anterior end; dorsal margin straight, meeting the posterior extremity at a sharp angle, and descending gently toward the anterior extremity;

ventral margin straight to the anterior extremity, where it is slightly concave; anterior extremity somewhat depressed, broadly round, more or less oblique toward the dorsal side, shallowly convex and overhanging the ventral margin; anterior margin raised to a narrow, low but distinct, ridge, fringed on its outer side with a row of minute teeth, and bordered on the inner side by a threadlike furrow; posterior extremity much depressed, thin, produced into a triangular beak with the two sides almost equal, meeting at the zenith of the beak; lower portion of the beak very slightly convex, fringed with a row of minute teeth (about twelve); upper portion of the beak, straight, uniting the zenith with the antero-dorsal-cardinal angle; valves each ornamented with a highly polished, small, translucent bead placed near the antero-dorsal-cardinal angle; greatest convexity of each valve rising abruptly above the postero-ventral portion of the beak; often passing into a faint slightly convex ridge, which runs for a short distance along the ventral margin; a small, subcentral, rounded lobe placed nearer to the anterior end of each valve; surface punctate, the small, semicircular pits arranged in horizontal rows along the central portion of the shell, the larger pits lining the inner border of the anterior ridge, the beak and the ventral margin; inner surface of the shell showing the shadows of the pits; hinge-line of the right valve very narrow, long, and straight, terminated at each end with a shiny oval tooth and a small socket; hinge-line of the left valve provided with a crenate bar and socket at each end; anterior and posterior extremities broadly flanged; ventral margin laminated; color porcelain-white, creamy, or yellow.

Locality: Orell's Crossing, very rare. Evergreen Crossing, common.

CYTHERE EVERGREENICA, sp. nov.

Plate 39, fig. 25

Shell oblong, biconvex, depressed, translucent, ornate; valves unequal, the left valve larger and overlapping the right valve slightly along the the dorsal and ventral margins; dorsal and ventral sides converging slightly toward the posterior extremity; dorsal margin slightly sinuate, narrow, more or less thickened at the antero-dorsal-cardinal angle; ventral margin gently convex; anterior extremity thick, broad, strongly convex, round toward the ventral side, oblique toward the dorsal, slightly depressed at the anterior margin; posterior extremity much narrower, more depressed, slightly produced into a subacutely rounded beak, convex toward the ventral side, distinctly angular toward the dorsal side; a small slightly arched, rather faint ridge near the dorsal margin between the central and the posterior sides of the test; surface covered by longitudinal, obliquely parallel riblets; two of these little ribs, one on each side of the center of the shell, more prominant than the rest; surface minutely punctate in the central region of the shell.

Only one specimen of this species was found in the collection. Consequently the definition is not complete.

Locality: Evergreen Crossing.

CYTHERE LEEANA, sp. nov.

Plate 39, fig. 26

Shell small, biconvex, inflated, compressed toward the extremities, translucent too opaque, and ornate; valves equal, except for the minute overlap of the right valve by the left along the upper portion of the extremities; proportion between length and height 7:4, the greatest height being near the anterior extremity; dorsal margin straight, except at the point of the dorso-anterio-cardinal angle, where it is thicker and raised somewhat; ventral margin almost straight, slightly concave a little off the center; anterior extremity broadly rounded, gently convex toward the ventral side, slightly oblique toward the dorsal side, raised a little, with a row of minute teeth, on the anterior margin; a shallow furrow following the anterior thickening; posterior extremity much narrower and gently depressed, and produced into a well-developed, angular beak, in the lower part, but strongly concave in the upper part, and meeting the dorsal margin at a sharp angle; beak truncate, longer at the base, shorter at the sides, and with small, sharp teeth distributed at regular intervals; valves each ornamented with a small, shiny, translucent bead placed below the antero-dorsal-cardinal angle, and with a small, faint, subcentral lobe and a short, shallow, arching dorsal ridge springing from the margin of the beak, terminating before reaching the anterior extremity, and highest at the anterior end; ventral ridge almost parallel to the ventral margin, rising from the swelled portion of the test just above the base of the beak and terminating before reaching the anterior extremity; surface punctate, with minute pits arranged in more or less parallel rows, faintest at the central portion of the shell, clearest and largest along the ridges, the margins, and the beak; hinge-line of the right valve well developed, straight, and long, with a small, sharp, translucent tooth and a small cavity at each end; hinge-line of the left valve narrow and long, with a small cavity at each end; ventral margin slightly laminated; anterior and posterior margins flanged; color porcelain-white, creamy yellow, or brown.

Cythere leeana is found at Moseley's Ferry, in the Cook Mountain formation, Eocene, of Texas.

Locality: Orell's Crossing, rare. Evergreen Crossing, very common.

CYTHERE ORELLIANA, sp. nov.

Plate 39, figs. 8–10

Shell small, slender, oblong, biconvex, opaque or translucent, ornate; valves unequal, left valve slightly larger with thicker margins; proportion between length and height 2:1, the greatest height being at the anterior extremity; dorsal and ventral margins nearly parallel; dorsal margin long and straight, except at the antero-dorsal cardinal angle, where it is raised and thickened; ventral margin slightly concave at the center; anterior extremity broad, convex; posterior extremity narrower, triangular with the postero-ventral side longer; anterior margin raised into a strong, curving ridge with a row of minute teeth on the flange, a row of

small, regular knobs on the crest of the ridge, and a deep furrow, following the outline of the ridge; posterior margin made of a triangular flange with a row of strong teeth on its lower border and a threadlike furrow following the outline of the flange and continuing for a short distance along the ventral margin; valves ornamented near the antero-dorsal-cardinal angle with a small, shiny, translucent bead; surface of the shell covered with a network of small, threadlike ridges, which are the walls for the tiny five-cornered pits, with knobs and spines; a row of these spines placed along the ventral and dorsal margins; walls of the valves thin, often bearing marks corresponding to the outer reticulation of the shell; hinge-line of the right valve narrow, straight, and long, extending from one extremity to the other; a small oval, and translucent tooth and a small cavity at each end of the hinge-line; hinge-line of the left valve thicker, grooved, with a horseshoe cavity at each end; color porcelain-white, creamy, yellow, or brown.

Locality: Price's Crossing, Orell's Crossing, and Evergreen Crossing. Rare.

CYTHERE TEXANA, sp. nov.

Plate 39, figs. 11, 12

Dorsal view oblong, with slightly produced extremities; ventral view obovate with slightly truncate extremities; shell small, stout, subquadrate, biconvex, translucent or dull, ornate; valves unequal, left valve being slightly larger; proportion between length and height 2:1 in slender individuals, 17:11 in stout ones; greatest height at the anterior extremity; dorsal margin nearly parallel to the ventral margin, long and straight, thickened and raised somewhat at the antero-dorsal angle, crenulate or spinose; ventral margin almost straight, slightly concave near the anterior side, crenulate or spinose; anterior extremity thick, broad, strongly convex, very slightly oblique toward the dorsal side; posterior extremity narrower, somewhat angular, oblique; postero-ventral curve longer than the postero-dorsal; anterior margin thick, raised into a curving ridge, with a row of small teeth on its lower margin and a distinct furrow following the outline of the ridge; posterior margin slightly flattened or flanged, with strong teeth or crenulations, and a threadlike furrow, following the outline of the flange, continuing sometimes for some distance along the ventral margin; valves ornamented with a glistening, translucent, or, in rare cases, dull bead placed below the antero-dorsal-cardinal angle; surface ornamentation extremely varied; dorso-marginal and ventro-marginal ridges present, spinose, crenulated, or nearly smooth; dorsal ridge straight, angular at the ends, running parallel to the dorsal margin between the extremities; ventral ridge, beginning near the posterior end, running convexly toward the anterior end and terminating before reaching it; subcentral lobe prominent or faint, round, elongate or horseshoe in form; valves marked by two, three, or more somewhat oblique, continuous or interrupted ridges running from the lobe toward the posterior extremity, and ending before reaching it; walls of the valves of medium thickness, often bearing marks corresponding to the outer markings of the shell; hinge-line of the right valve narrow, straight, and long, extending from one extrem-

ity to the other; a small, oval, and translucent tooth and a small cavity placed at each end of the hinge-line; hinge-line of the left valve thicker, with a horseshoe cavity at each end; ventral margin laminated; anterior and posterior margins flanged; color porcelain-white, yellow, or brown.

Cythere texana somewhat resembles *Cythereis ciliata* Reuss, a common species of the Upper Cretaceous of Europe, but it may be easily distinguished from the latter by its thick and raised extremity. *Cythereis ciliata* has a depressed or flanged and often bearded anterior side.

Locality: Orell's Crossing and Price's Crossing, common. Evergreen Crossing, Lee County, Texas, very common.

Genus CYTHERIDEA Bosquet, 1852

CYTHERIDEA MÜLLERI Münster

Plate 39, figs. 13–17

Cythere mülleri MÜNSTER, Jahrb. f. Min., 1830, p. 62; and Neues. Jahrb. f. Min., 1835, p. 446.

Cytherina mülleri RÖMER, Neues. Jahrb. f. Min., 1838, p. 516, pl. 6, fig. 6.—REUSS, Haidinger Abhandl., vol. 3, 1850, p. 55, pl. 8, fig. 21.

Cytheridea mülleri BOSQUET, Mém. Couron. Acad. Belg., vol. 24, 1852, p. 39, pl. 2, fig. 4.—JONES, Paleont. Soc., London, 1855, p. 41, pl. 5, figs. 4 *a–c*, 5; pl. 6, figs. 10 *a–b*, 11–13.—SPEYER, Die Ostrac. der Casseler Tertiärbild., 1863, p. 48, pl. 1, fig. 8.—G. S. BRADY, Trans. Zoöl. Soc., vol. 10, 1878, p. 397, pl. 62, figs. 4 *a–c*.—TERQUEM, M. O. Mém. Soc. Géol. France, 1878, p. 125, pl. 14, figs. 19 *a–d*.—LIENENKLAUS, Mon. n.-w. Deutschl., Zeitsch. d. deutsch. geol. Ges., vol., 1894, p. 220.—LIENENKLAUS, Abhandl. der Schweizer palaontol. Ges., vol. 22, 1896, p. 25, pl. 2, figs. 5 *a–b*.—CUSHMAN, Bull. Amer. Assoc. Petrol. Geol., vol. 9, 1925, pl. 8, figs. 4 *a–c*, 5.

Bairdia hagenowi, REUSS, Zeitsch. d. deutsch. Geol. Ges. 1855, p. 60, pl. 9, fig. 93.

Cytheridea heterostigma, REUSS, *ibid.*, 1855, p. 60, pl. 9, fig. 94.

Shell small, ovate, or subovate to subtriangular, elongated, ornate, biconvex; valves unequal, left valve larger and overlapping the right; overlap greatest around the dorsal margin, very slight around the ventral margin and the extremities; dorsal margin strongly arched, its posterior and anterior sides subparallel; ventral margin of the left valve slightly convex or straight; ventral margin of the right valve straight or slightly concave; anterior end broadly rounded, flanged; posterior end narrow, obliquely rounded, truncate near the ventral margin; flanges thin, more or less broad with eight sharp teeth on each valve; teeth rarely perserved; long slender spines sometimes placed near the ventral side of the posterior end of the right valve; number of teeth from six to eight, proportion between length and height a little less than 2:1; greatest height a little off the center, nearer to the anterior end; surface thickly covered with rounded depressions of medium size, which sometimes are arranged in curved transverse furrows; color white, yellow, or brown.

Cytheridea mülleri is found in rather shallow sea waters. It is recorded from Smyrna, the Levant, Australia, and Zuyderzee, Holland (G. S. Brady).

Fossils of this species have been recorded from the Eocene of Texas (Cook

Mountain formation), Mexico (Mostezuma River) (Cushman), Australia, Bohemia, Germany, France, and Holland (G. S. Brady, Bosquet); the Miocene of Touraine and Holland (G. S. Brady); the Pliocene of Belgium (Bosquet); the Upper Oligocene of Cassel, in Westfalia, Germany; the Middle Oligocene, near Bern in Switzerland (Lienenklaus); and the blue Tertiary clays of Australia (R. Jones).

Locality: Evergreen Crossing and Orell's Crossing, common. Price's Crossing, Lee County, Texas, rare.

Genus CYTHEREIS Jones, 1849

CYTHEREIS BURSILLOIDES, sp. nov.

Plate 39, figs. 21–23

Shell small, oblong to subrhomboidal, biconvex, compressed and highly ornate; valves equal, proportion between length and height 7:4, the greatest height being near the anterior extremity; dorsal margin straight for almost its whole length, except at the point of the antero-dorsal-cardinal angle, where it is thickened and somewhat raised; ventral margin slightly concave; anterior extremity broadly rounded, gently convex toward the ventral side, somewhat oblique toward the dorsal side; anterior margin thick, with a row of minute teeth on the lower part of the margin of each valve; posterior extremity much narrower, obtusely rostrate between the center of the posterior extremity and the ventral margin, slightly concave between the center and the dorsal margin; beak spinose; spines fewer (four to seven), but larger than those of the anterior margin; surface of the shell covered with a net of ridges, forming meshes irregular in form and size, and four- or five-cornered; mesh smaller at the center, growing larger toward the margins; wall of the mesh threadlike and clear; cells of the mesh filled with a dull matter; a large, slightly raised and much flattened lobe placed a little off the center of the shell, nearer to the anterior extremity; two parallel ridges, a little more prominent than the net, running from the lobe toward the posterior extremity, the one suddenly curving toward the dorsal margin, where it unites with the dorsal ridge, the other turning toward the ventral margin and uniting with the ventral ridge; dorsal ridge thick, starting at the ventro-cardinal angle, arching for two-thirds of its length, oblique at the last third, and ending abruptly before reaching the anterior extremity; ventral ridge thick, longer than the dorsal ridge, almost parallel to the ventral margin, slightly convex, starting a little below the base of the beak, and ending abruptly before reaching the anterior extremity; each valve ornamented with a minute, highly polished, and translucent bead placed a little below the antero-dorsal-cardinal angle; the shell medium thick and covered with marks, which more or less correspond to the meshes on the outside of the test; hinge-line of the right valve narrow, long, and straight, with one translucent tooth and a little socket adjacent at each end; tooth at the antero-cardinal angle conical, larger and sharper than the tooth at the postero-cardinal angle, which is oblong;

hinge-line of the left valve straight, wider, and slightly grooved, with a semicircular socket at each end; color creamy, yellow, or white.

In this species the left valve occasionally overlaps the right at the antero-dorsal-cardinal angle, due apparently to pressure. The teeth on the margins are often destroyed and the lobe and the two parallel ridges are sometimes obscured by the net. In the ventral view the shell is flat, broadest at the center, narrowing toward the extremities; in the dorsal view it is ovate, with truncate ends.

Cythereis bursilloides is found at Moseley's Ferry, Cook Mountain formation, of Texas.

Locality: Evergreen Crossing, Lee County, Texas, extremely common. Orell's Crossing, Lee County, Texas, rare.

CYTHEREIS DAVIDWHITEI, sp. nov.

Plate 39, fig. 24

Shell minute, elongate-ovate, biconvex, depressed somewhat toward the extremities and the ventral side, ornate; ventral and dorsal views very similar; lanceolate with truncated ends; valves equal; proportion between length and height 7:4, the greatest height being at the anterior extremity; dorsal and ventral margins nearly parallel; dorsal margin straight to the antero-dorsal-cardinal margin, where it is slightly raised and thickened; ventral margin straight; anterior extremity broadly rounded; anterior margin raised into a strong ridge, convex toward the ventral margin, oblique and protruding over the dorsal margin; posterior extremity much narrower, one-half the width of the anterior extremity, much depressed and produced into an angular beak, with the two sides straight and almost equal, meeting sharply at the zenith, strongly crenulate at the margin, spinose on the surface, and bordered by a shallow furrow at the inner end of the beak or at the base of the greatest swelling; surface of each valve ornamented with a tiny, highly polished, and translucent bead; central lobe small, round, rising into a spine; several other spines and smaller lobes scattered irregularly over the central portion of the shell; a row of several, irregularly spaced, longer and larger spines trending along the dorsal margin, suddenly turning at and along the posterior convexity, crossing the valve on the crest of the latter and then descending to the ventral side and running along the ventral margin.

Locality: Evergreen Crossing and Orell's Crossing, extremely rare. Price's Crossing, very rare.

CYTHEREIS ELMANA, sp. nov.

Plate 39, fig. 20

Shell small, oblong to subquadrate, biconvex, more or less depressed toward the extremities, translucent to opaque, ornate; valves equal, the proportion between length and height being 7:4; greatest height at the anterior extremity; dorsal margin straight, except at the antero-dorsal-cardinal angle, where it is raised slightly and thickened; ventral margin almost straight; anterior extremity

broadly rounded, gently convex toward the cardinal angles and thickened along the anterior margin, forming a ridge, which is much broader and slightly higher at the dorso-cardinal angle; a rather deep, narrow furrow following along the inner margin of the ridge; anterior margin set with a row of blunt, minute, sub-equal teeth; posterior extremity narrower, much depressed, slightly produced into an angular beak, crenulated at the margin and outlined by a shallow furrow, which is continued to the ventral side for a little distance; valves ornamented each with a small glistening bead placed below the antero-dorsal-cardinal angle; dorsal ridge, strong, almost straight or slightly concave at the posterior angle, slightly arched and oblique at the anterior side, where it terminates, and is fringed with five to six short, blunt, sub-equal teeth; central part of the test occupied by several lobes; anterior lobe kidney-shaped, starting just below the base of the dorsal ridge, and terminating at the ventral margin, just short of the ventral lobe; ventral lobe elongated, swelled like the anterior lobe, occupying the rest of the ventral side, terminating above the posterior furrow; central lobe parallel to the ventral lobe, somewhat flask-shaped, with the narrower part toward the posterior side; surface depressed between the lobes; hinge-line of the right valve long, narrow, terminating at each end with a small, shiny tooth and a socket; hinge-line of the left valve provided with a bar and two sockets; color yellow.

Locality: Evergreen Crossing. Extremely rare.

Genus CYTHEROPTERON Sars, 1865

CYTHEROPTERON VIRGINEUM Jones

Plate 39, figs. 4–7

Cythere punctatula (not RÖMER), var. *virginea* JONES, Mon. Entom. Cret., Palaeograph. Soc. 1849, p. 12, pl. 1, fig. 2 n.—BOSQUET, Mém. Couron. Acad. Belg., vol. 24, 1852, pp. 73, 74, pl. 3, figs. 10 *a–d*.

Cypridina (*Cytherina* on the plate) *Althi*, Reuss, 1850, Haidinger Abhandl., vol. 4, pt. I, p. 49, pl. 6, figs. 10 *a–c*.

Cythere concentricum, var. *virginea* REUSS, Elbthalgeb., 1874, p. 145.

Cythere virginea JONES, Syst. Lists, Belfast Nat. Club, vol. 1, Append. 3, 1875, pp. 81, 92.

Cytheropteron concentricum (REUSS), var. *virginea* (vel. *concentricum-virgineum*) JONES, Supp. Mon. Cretac. Entom. of England and Ireland, Palaeograph. Soc., 1890, p. 32, pl. 1, figs. 14–17.

Shell smooth, strong, translucent, subrhomboidal or ovate, biconvex, much inflated, greatest swelling near the ventral side, more or less depressed at the extremities and at the ventral side; proportion between length and height 9:6; the greatest height at the middle of the test; valves unequal and of a slightly different shape; right valve larger and overlapping the left very slightly along the dorsal margin; dorsal margin strongly arched, descending abruptly toward the extremities, convex toward the anterior end, oblique toward the posterior end; ventral margin straight, slightly sinuate in the central portion, depressed; ventral side broad, having the outline of an irregular hexagon with slightly emarginated extremities, depressed somewhat at the ventral margin, rising in a gentle convex

curve toward the borders, terminated by the longitudinal ridges, that mark the maximum swelling of each valve; a short, threadlike furrow between the center of the ventral margin and the posterior base of the crown of each valve; crown narrow, strongly arched, running longitudinally between the extremities of each valve, but abruptly terminating before reaching either of them; anterior extremity broadly convex, strong, more or less depressed at the margin; anterior margin ornamented in its lower part by three to six, short, broad, nearly equal teeth, and several smaller teeth situated in the upper part of the margin; posterior extremity much narrower and greatly depressed, produced into a prominent subacute beak in the lower part of the extremity, strongly oblique at the upper portion; hinge-line of the right valve slightly shorter than the dorsal margin, narrow, straight, terminated at each end by a small tooth; hinge-line of the left valve wider, with a crenate median bar; posterior and anterior extremities flanged; ventral margin slightly laminate; color porcelain white, creamy, or yellow.

Cytheropteron virgineum greatly resembles the recent species *Cytheropteron laeve* Brady and Norman, but the latter has a much higher test and a narrower anterior end.

Cytheropteron virgineum has been found in the Upper Cretaceous and Tertiary of Europe; in the Chalk of Keady Hill, Dunstable, Ditcot, and Dover (Jones); in the Gault of Folkstone and Leacon Hill (Jones); in the Greensand of Cambridge and Warminster (Jones); in the Upper Cretaceous at Maastricht (Bosquet); in Rügen in Bohemia (Reuss); in Gosau (district of Salzkammergut), in the Eastern Alps (Jones); in the Lower Cretaceous, of Haute-Marne, in France (Cornuel); in the Eocene of France (Bosquet); in the Cook Mountain formation, Eocene, of Texas.

Locality: Evergreen Crossing, Lee County, Texas, common. Orell's Crossing, Lee County, Texas, very rare. Price's Crossing, rare.

Family CYTHERELLIDAE

Genus CYTHERELLA Jones, 1849

CYTHERELLA TEXANA, sp. nov.

Plate 39, fig. 18

Shell very small, ovate, thin, smooth, biconvex, compressed; valves unequal; right valve much larger and overlapping the left valve, the greatest overlap being around the dorsal margin; proportion between length and height about 9:6, the greatest height being a little off the center; dorsal margin of right valve arched; dorsal margin of left valve slightly curved, passing obliquely toward the posterior end; ventral margin of right valve slightly convex; ventral margin of left valve almost straight, gently curving toward the extremities; left valve narrow, elliptical in outline, with a small muscle-scar faintly seen a little below the center; anterior and posterior extremities of both valves rounded; anterior end broader, thinner and more compressed; posterior end narrower, obliquely rounded, thicker and more convex; color porcelain-white or yellow.

Cytherella texana is nearly allied to *Cytherella ovata* Römer but has a more symmetrical test, a higher dorsal arch, a more obliquely rounded posterior end, and is smaller.

Locality: Orell's Crossing, Evergreen Crossing, and Price's Crossing. Rare.

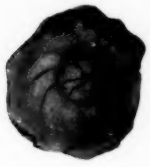
EXPLANATION OF PLATES

PLATE 38

FIGS. 1–5.—*Eponides texana*, sp. nov. 1, 4, superior view; 2, 3, inferior view; 5, side view.
6–8.—*E. patelliformis*, sp. nov. 6, superior view; 7, side view, 8, inferior view.
9–11.—*Ceratobulimina eximia* (Rzehak). 9, superior view; 10, inferior view; 11, side view.
12, 13, 29.—*Cristellaria rotulata* (Lamarck). 12, side view; 13, side view of another specimen; 29, peripheral view.
14.—*C. orelliana*, sp. nov. Side view.
15.—*C. torrida* Cushman. Side view.
16, 17.—*Polymorphina problema* d'Orbigny. 16, side view; 17, apertural view of another specimen.
18, 19.—*P. regularis* Münster. 18, side view; 19, side view of another specimen.
20–22.—*P. gibba* d'Orbigny. 20, side view; 21, apertural view of another specimen; 22, side view.
23, 24.—*Quinqueloculina claiborniana*, sp. nov. 23, side view; 24, side view of another specimen.
25–27.—*Q. vulgaris* d'Orbigny. 25, 26, side views; 27, apertural view.
28.—*Q. seminulum* (Linné). Side view.

PLATE 39

FIGS. 1–3.—*Bairdia oviformis* Speyer. 1, right valve; 2, left valve; 3, dorsal view.
4–7.—*Cytheropteron virgineum* Jones. 4, ventral view; 5, dorsal view; 6, oblique view; 7, left valve.
8–10.—*Cythere orelliana*, sp. nov. 8, right valve of a variety differing from the typical form of the species in the ornamented surface; 9, ventral edge of an entire test; 10, right valve of typical specimen.
11, 12.—*C. texana*, sp. nov. 11, large left valve; 12, small left valve.
13–17.—*Cytheridea mülleri* (Münster). 13, right valve; 14, left valve showing elongated surface markings; 15, right valve; 16, dorsal margin; 17, ventral margin.
18.—*Cytherella texana*, sp. nov. Left valve.
19.—*Cythere claiborniana*, sp. nov. Right valve showing delicate surface markings.
20.—*Cythereis elmana*, sp. nov. Left valve.
21–23.—*C. bursilloides*, sp. nov. 21, left valve of typical form; 22, right valve; 23, ventral edge.
24.—*C. davidwhitei*, sp. nov. Left valve.
25.—*Cythere evergreenica*, sp. nov. Right valve.
26.—*C. leeana*, sp. nov. Left valve.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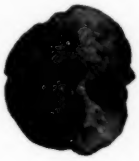
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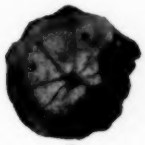
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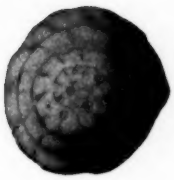
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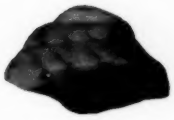
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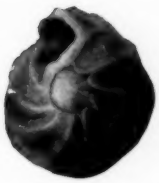
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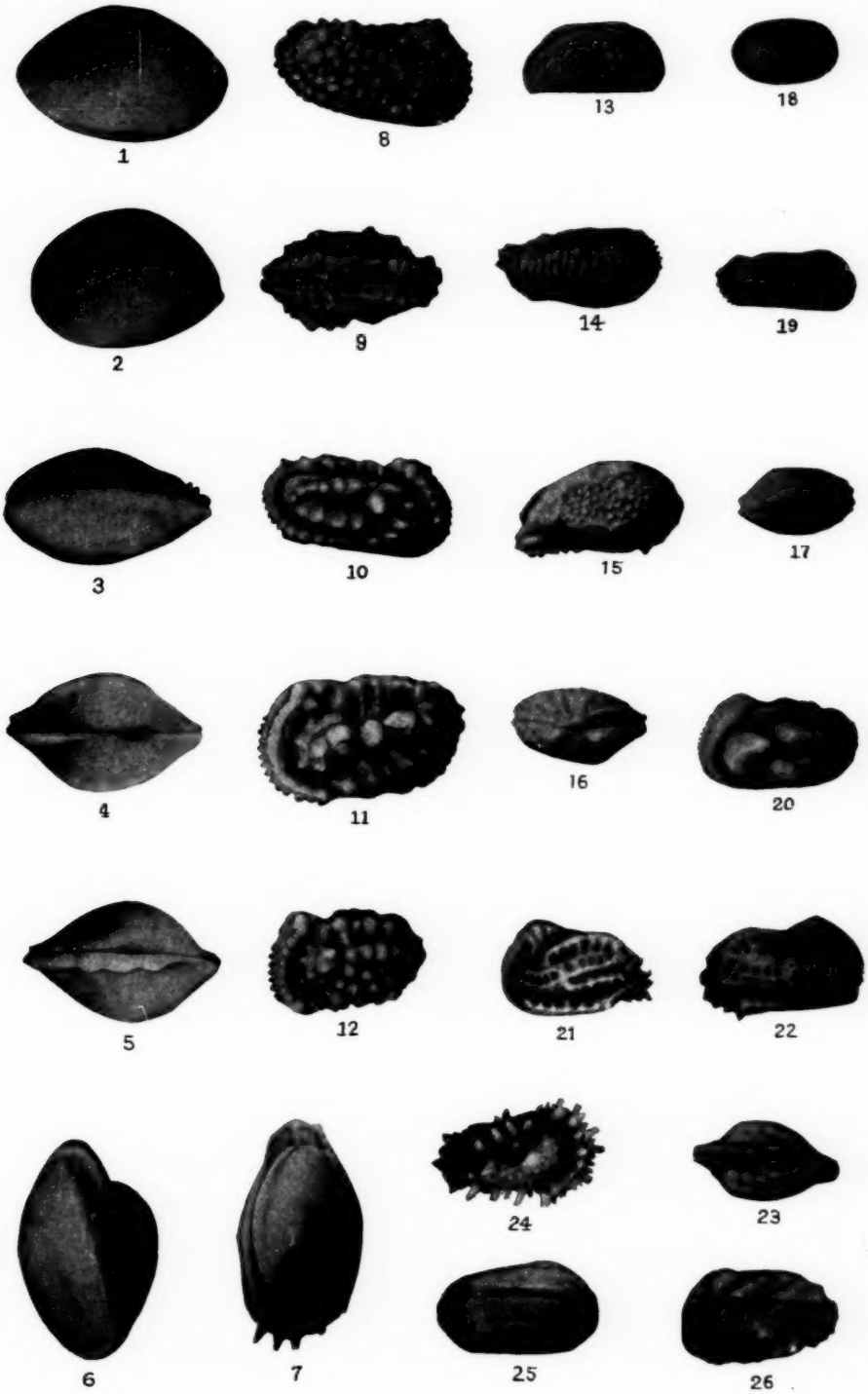
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THE CORRELATION OF THE MARINE YEGUA OF THE TYPE SECTIONS[1]

JULIA GARDNER
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The Yegua formation has suffered the usual nomenclatorial vicissitudes of a series in large part non-marine, variable in lithology, and not abundantly fossiliferous. Though type sections are, unfortunately, not always typical, they at least indicate what the author had in mind when he named the formation, and cannot be disregarded. Probably no more debatable section could have been chosen than that selected as the type of the Yegua. Collections made during two short field excursions on Yegua Creek and its tributaries have yielded results which make it advisable to reconsider the correlation of the Yegua formation.

Beds now referred to the Yegua were originally included in Penrose's[2] Fayette, 1890, which embraced "All those beds found on the Brazos, Colorado, and Rio Grande which lie between the uppermost fossiliferous strata of the marine Tertiary below and the post-Tertiary clays, limestones, and pebble beds above."[3] Because of an apparent lithologic similarity, they were considered the equivalent of the "Grand Gulf series" of Hilgard's Mississippi section and were referred by Heilprin[4] with some misgivings to the Miocene.

Kennedy[5] two years later subdivided the so-called "Miocene" into (1) the Lufkin or Angelina County deposits, (2) the Fayette sands, and at the top (3) the Fleming beds. The "Lufkin or Angelina County deposits" were, by definition, "made up chiefly of dark blue gypseous clays, and gray sands containing quantities of saline matter. These beds also contain lignite, in many places in beds or deposits of considerable extent."[6] The series was traced westward across the Neches to the Trinity in Houston County, but no mention was made of a Lee County outcrop.

The commissioner's letter of transmittal of the *Third Annual Report* was dated May 1, 1892, and a report by Dumble on the brown Coal and lignite of Texas was transmitted on November 1 of the same year, and apparently published before the end of the year. Dumble's report established a Yegua "division" to which he referred "the lower portion of the deposits heretofore classed as Fayette beds."[7]

[1] Published by permission of the director of the U. S. Geological Survey.

[2] R. A. F. Penrose, Jr., "A Preliminary Report of the Geology of the Gulf Tertiary of Texas from Red River to the Rio Grande, 1890," *Geol. Survey Texas, 1st Ann. Rept.* (1890), pp. 5–101.

[3] *Ibid.*, p. 47.

[4] Angelo Heilprin, *Contributions to the Tertiary Geology and Paleontology of the United States* (1884), p. 39.

[5] William Kennedy, "A Section from Terrell, Kaufman County, to Sabine Pass on the Gulf of Mexico," *Geol. Survey Texas, 3d Ann. Rept.* (1892), pp. 43–125, text figs. 3–6.

[6] *Ibid.*, p. 58.

[7] Edwin T. Dumble, "Report on the Brown Coal and Lignite of Texas," *Geol. Survey Texas* (1892), pp. 1–243, pls. 1–25, 13 text figs.

Though in 1918 Dumble wrote: "The original differentiation [from the Fayette] resulted from an examination made by the writer and party in 1892, starting from Giddings and going northeastward along Elm Creek, a branch of the Yegua," he made no reference in his original description to the Lee County sections, but considered only the East Texas, Brazos River, Colorado River, and Rio Grande sections. In none of these did he recognize a marine fauna. The Yegua was, however, included in the Eocene because of marine Eocene fossils found in the overlying Fayette.

In 1894 Dumble published in the *Journal of Geology*[1] a much more detailed discussion of the Yegua clays. His description, given at that time holds good, with minor modifications, in the light of subsequent research:

> The clays are dark blue, weathering to a dirty yellow, with a profusion of crystals of gypsum. In places the clays are massive, at others laminated. The sands are gray and white, often laminated or cross-bedded, but sometimes massive. The fossil wood contained in them is simply silicified and not opalized, as in the succeeding beds. The brown coal and lignite deposits of this sub-division are as extensive as those of the lignitic stage, beds with a measured thickness of sixteen feet having been observed on the Colorado.
>
> While the lithologic characters of the Yegua clays are clearly marked and plainly traceable entirely across the State, its fauna connects it directly with the marine beds. Typical exposures of the beds may be seen near Alto and Lufkin, on the Yeguas in Lee County, and between Pleasanton and Campbellton.[2]

In the January-March number of the *Proceedings of the Academy of Natural Sciences, Philadelphia*,[3] Kennedy published a long discussion of "The Eocene Tertiary East of Brazos River." He contributed little, however, to the elucidation of the Yegua beyond a few non-marine sections and the unfortunate suggestion that the lignito-gypseous beds of Louisiana were the equivalents of the Frio clays while the Yegua clays and the Fayette sands did not persist east of the Sabine.

New light upon the equivalents of the Yegua was given by the publication, in April of 1895, of Vaughan's "Cocksfield[4] Ferry Beds" of Louisiana,[5] a formation strikingly similar in general lithologic character to the Yegua. Near Montgomery the marine Jackson is well developed, and the "Cocksfield Ferry" (later abandoned by the U. S. Geological Survey in favor of Yegua), falling between the St. Maurice, which carries a lower Claiborne fauna, and the rich marine Jackson of Montgomery, was correlated with the upper Claiborne, though with the reservation that "one cannot state exactly how much or what part of these beds represent the Claiborne sands."[6] No attempt toward any correlation with the Texas section was made.

[1] E. T. Dumble, "The Cenozoic Deposits of Texas," *Jour. Geol.*, vol. 2, no. 6 (1894), pp. 549–67.

[2] *Ibid.*, p. 552.

[3] William Kennedy, "The Eocene Tertiary of Texas East of Brazos River," *op. cit.*, 1895, pp. 89–160.

[4] The name first appeared as "Cocksfield" but was corrected by Veatch, in 1906, from the U. S. engineers' maps of the Red River Survey to "Cockfield."

[5] T. W. Vaughan, "The Stratigraphy of Northwestern Louisiana," *Amer. Geologist*, vol. 15 (1895), pp. 205–29, pl. 9.

[6] *Ibid.*, p. 220.

The Louisiana sections of the Yegua seem to have been more illuminating than those west of the Sabine, for Harris,[1] in 1902, reaffirmed the correlation of the "Cocksfield Ferry" with the upper Claiborne of east Mississippi and Alabama; and Veatch,[2] in the same report, published a small correlation table of Kennedy's Texas section and the standard section of Louisiana. In this, the Yegua clays were considered the equivalent of the "Cocksfield" and of the greater part of the Jackson, though the basal Fayette of Texas was correlated with the topmost Jackson of Louisiana.

Dumble,[3] in October of the same year, published a reactionary criticism in which he doubtfully correlated the "Cocksfield Ferry" with the Yegua, and postulated a considerable hiatus between the "Cocksfield Ferry" and the Jackson and an overlap of the Jackson concealing both the Fayette and the Frio in Louisiana.

Deussen, in the "Geology and Underground Waters of the Southeastern Part of the Texas Coastal Plain," formulated the opinion now generally accepted:

> In 1892 Dumble recognized the lignitiferous unit here considered as a separate formation and applied to it the name Yegua. This same lithologic unit was described in Louisiana in 1895 by Vaughan as the "Cocksfield Ferry beds." . . . . Recent investigation has shown that the lithologic unit described by each of these investigators is the same throughout and is stratigraphically continuous from western Louisiana far into Texas, representing in eastern Texas the time equivalents of the "Upper Claiborne" deposits of the Gosport sand of Alabama.[4]

Detailed sections from the beds of the Brazos and the Sabine rivers were given.

In the September-October number of the *Journal of Geology*, 1915, Dumble,[5] without considering the floral evidence, reasserted the lower Claiborne age of the Yegua and remarked: "It has been suggested that the so-called Cocksfield Ferry beds on the Sabine might be of upper Claiborne age, but they have been connected by careful tracing with the basal Yegua and are, therefore, lower Claiborne." This position was maintained without argument in the "Problem of the Texas Tertiary Sands,"[6] published in December of the same year.

The first detailed discussion of the sections in Lee County appeared in Dumble's "Geology of East Texas."[7] Under the caption, "The type sections,"[8] he gave a generalized section of the area and five detailed sections on Elm Creek and near the mouth of Elm Creek on the (West) Yegua. He also gave for the first time the evidence for his strong conviction of the lower Claiborne age of the Yegua—the lists of the marine fossils from the basal gypsiferous beds of the Elm Creek sections.

[1] Gilbert D. Harris, "The Tertiary Geology of the Mississippi Embayment with Special Reference to the State of Louisiana": *A Report on the Geology of Louisiana, Special Report No. 1* (1902), p. 21; pls. 1–10; 7 text figs.

[2] A. C. Veatch, "The Geography and Geology of the Sabine River": *A Report on the Geology of Louisiana; Special Report No. 3* (1902), p. 141.

[3] E. T. Dumble, "The Tertiary of the Sabine River," *Sci.*, new ser., vol. 16 (1902), pp. 670, 671.

[4] Alexander Deussen, *U. S. Geol. Survey Water-Supply Paper 335* (1914), pp. 65–66.

[5] E. T. Dumble, "Some Events in the Eogene History of the Present Coastal Area of the Gulf of Mexico in Texas and Mexico," *op. cit.*, vol. 23, no. 6 (September–October, 1915), p. 490.

[6] E. T. Dumble, *Geol. Soc. Amer. Bull.*, vol. 26 (1918), p. 459.

[7] E. T. Dumble, *Univ. Texas Bull. 1869* (1918).

[8] *Ibid.*, pp. 102–7.

These sections were visited by the writer in 1923 and 1924 and will be considered in greater detail shortly.

Deussen in the "Geology of the Coastal Plain West of Brazos River,"[1] offered a more extensive account of the Yegua than that published in 1914. Several sections from Lee County were given but none from Elm Creek and none carrying any marine fossiliferous beds, excepting those in southwest Texas. Mr. Deussen's paper, though published in 1924 was submitted almost ten years earlier, so that he did not have, when he wrote the paper, the knowledge of Dumble's emphasis upon the Elm Creek section 5 and their marine faunas.

The floral evidence was again stressed by Edward W. Berry in "The Middle and Upper Eocene Floras of Southeastern North America:"[2]

> The Yegua formation, which is said by Dumble to lie unconformably on the Cook Mountain, becomes more sandy and thicker toward the southwest. It is about 600 feet thick on Brazos River; 720 feet thick on Nueces River, according to Deussen; and from 1,000 to 1,400 feet thick on the Rio Grande, according to Dumble. In general, the Yegua is sandy at the top, lignitic in the middle, and clayey at the base. With the clayey strata gypsum and saliferous beds and limonitic concretions are associated. South of Guadalupe River the lignitic portion is near the top and is underlain by green gypsiferous clays, dark sands, that are in places glauconitic, and oyster beds.
>
> The flora found in the Yegua formation of Texas is not extensive enough to permit its exact correlation, but it indicates that the lithologic unit called Yegua is in part Claiborne and in part lower Jackson in age, and I have accordingly so considered it.

Elm Creek is easily accessible from Giddings, the county seat of Lee County. A short reconnaissance was made in 1923 in company with Mr. Robert Lee Cannon, and fairly good collections were made from the best of the sections the following year. The bluff near the mouth of Elm Creek on the West Yegua had slumped and was so completely overgrown that it offered no exposure. No good section could be found at Price's Crossing though there was a small outcrop of fossiliferous clays. Blue gypsiferous clays with incipient ferruginous concretions are exposed about 200 feet above Evergreen Crossing on the Giddings-Lincoln road. The associated fauna is more diversified than that from the other Elm Creek localities, but this is probably due to more favorable environmental conditions and not to any difference in age.

Dumble made the following generalized section of the Elm Creek exposures:[3]

1. Thin scattering gravel in places.
2. Thinly bedded and in places laminated sands and clays with lignitic sands and thin streaks of lignitic material.
3. Thinly stratified blue and brown clay weathering to a brownish yellow, the layers from ½ to 2 inches thick.

   These beds show also in places laminated dark blue and pinkish colored clays carrying large blocks of selenite enclosing small fossil forms.

[1] Alexander Deussen, *U. S. Geol. Survey Prof. Paper 126* (1924), pp. 75–80.

[2] *U. S. Geol. Survey Prof. Paper 92* (September 18, 1924), p. 9.

[3] E. T. Dumble, "Geology of East Texas:" *Univ. Texas Bull. 1869* (1918), p. 102.

4. Thin streaks of ferruginous material, probably originally carbonate of iron. This streak lies in the form of a pavement of kidney-shaped or ellipsoidal flattened boulders from one to three feet in length and from six inches to one foot in thickness. These boulders are usually concentric in structure and break in thin layers, but in some portions toward the head of the creek into square blocks. A thin streak of ferruginous or altered glauconitic sand underlies this pavement and is generally associated with it. This sand is highly fossiliferous and the fossils are usually fairly well preserved. These appear to have a strong Claiborne facies.
5. Laminated dark almost black clay. This clay breaks up into nodules or cuboidal blocks with rounded ends and carries a considerable fauna and also a small quantity of selenite. The fauna is usually found in nests or a large number in one place, while a considerable portion of the clay is barren. The bed is jointed and broken in places appears to be faulted. The joints are usually within a few degrees of perpendicular and are filled with thin sheets or plates of selenite. These beds are broken by a thin streak of ferruginous material similar to No. 4.
6. Pale bluish gray clay carrying fossils and gradually changing to a slightly altered glauconitic sand.

This appears to be the lowest visible in this section and is thought to be the top of the marine beds.

The best exposure observed in 1924 was that at Orell's Crossing over Elm Creek about 5 miles northwest of Giddings on the Manheim road. The bluff is less than a quarter of a mile upstream from the bridge. The following section was oberved in 1924:

6. Laminated sands and clays carrying some glauconite, lighter colored toward the top with thin layers of lignitic material and macerated leaves. Leaves occurring most commonly in the sandy layers ¼ inch to ½ inch in thickness in the upper half of the bed. The dark colored layers in the upper part of the section lignitic in character. Darker toward the base and containing casts in the lower portion of *Turritella*, *Alectrion*, *Leda*, etc., together with abundant selenite along the joint planes. Lower 6 feet or 7 feet more argillaceous than that above..... 15 ft.
5. Ferruginous layer often with a half-inch of closely packed shell marl beneath. Tendency toward concentric boulders less strong than in No. 3. In some parts of the section, notably the western end, this bed is a 6-foot to 8-foot series of interbedded dark blue shale, lighter blue sands and ferruginous clay—the sands as a rule carrying the fossils..... 6 in.
4. Black clays very similar to those of No. 1, carbonaceous, glauconitic in the sandy pockets, more massive in the lower portion, more thinly laminated, and less fossiliferous above. Sands even more pockety than in No. 1. Gypsum very common especially along the joint planes together with an Fe sulphate probably copiapite*.. 5 ft.
3. Ferruginous concentric boulders, flattened, discoidal, or reniform, sometimes highly fossiliferous and glauconitic..... 2 in.
2. Grading upward into a ferruginous sand; a fairly well defined layer in some places interbedded with dark clays. Highly fossiliferous and gypsiferous..... 2 ft. 6 in.
1. Black clay, possibly carbonaceous, well bedded, very brittle and chippy carrying some sand in pockets and thin layers. The sands glauconitic and usually carrying nests of fossils. *Alectrion* sp. the most common. *Cadulus*, *Ringicula*, *Nucula*, *Terebra*, etc. Gypsiferous..... 1 ft.

* Determined by Earle V. Shannon, U. S. National Museum.

Selenite occurs throughout the section, though perhaps most abundantly in bed No. 4 and the lower portion of No. 6. The mode of occurrence is fairly uniform —along the joint planes. No Mollusca were specifically determined from No. 6,

though they are apparently the common species of the beds below. The faunas of the other beds were studied individually but they present so few differences that they may be grouped in discussion. These differences are mainly those of relative abundance of species. The general character and ensemble of the fauna is strikingly similar throughout the five lower beds.

The Mollusca of the Orell's Crossing section may be considered as a unit and as representative of the marine Yegua of Elm Creek and of the Yegua near the mouth of Elm Creek. The relationships of the Mollusca in these the type sections of the Yegua are emphatically Cook Mountain and contain no element characteristic of the upper Claiborne biota. There is scarcely a species new or old which is not present in the Smithfield and Moseley's Ferry faunas. *Leda compsa* Gabb, *Latirus moorei* Gabb, and *Neverita arata* Conrad are all species of more than local distribution and are recognized horizon-markers of the earlier Claiborne since Harris's first determinations published in 1894. The later investigations of the molluscan fauna have corroborated the earlier conclusions, and further evidence of the same nature has been brought forward by the study of the Foraminifera and the Ostracoda. The fauna is not, however, a typical Cook Mountain fauna, such as that at Smithfield or Moseley's Ferry, or the slightly later fauna of Alabama Crossing on the Trinity River. The number of species is restricted, and many of them present a depauperate aspect indicating a struggle with an unfavorable environment. The leaves in the upper part of the section are all macerated and probably do not signify true continental conditions. However, superficially similar gypsiferous leaf-bearing clays, such as those developed in the upper 10 to 15 feet at Orell's Crossing, are traceable eastward to the Sabine, and continue across Louisiana and Mississippi under the name of "Yegua."

Two interpretations of the type section are possible:

The Yegua was a period of elevation and was initiated by the retreat of the sea. Lagoon conditions developed, not only on Elm Creek, which is about midway between the Brazos and Colorado rivers, but also near Edge in northern Brazos County between the Brazos and Navasota rivers, and doubtless at a number of other localities not so well known. Many of the faunas collected from the St. Maurice of Louisiana present a marked similarity to those of Lee County, and it is highly probable that fringing lagoons were developed as far east as the old Mississippi. The reaction upon a fauna during a period of elevation is necessarily quite distinct from that accompanying a sinking shore line. An advancing sea brings new faunal elements which mingle with the old and either destroy or modify them. The accompanying changes in temperature with shifting ocean currents are quickly and strongly reflected in the biota. In a retreating sea such as that inaugurating the Yegua, the marine life is caught and more or less isolated in partially inclosed waters becoming increasingly saline. No new element enters in, and the fauna is modified only by the disappearance of the more specialized forms and the adaptation of some of the more plastic. The retreat of the shore line which marked the inception of the Yegua gave rise to local lagoons in which the Cook Mountain

fauna was doubtless able to survive in a reduced state for a short space of time. Because this fauna was cut off from contact with other faunas evolving to the eastward in free communication with the changing life of the open sea, its affinities would be entirely with the past. The Elm Creek faunas may perhaps be interpreted as a trapped Cook Mountain fauna persisting from earlier to later Claiborne time, their biological associations entirely with the earlier but historically allied to the later since they have survived the retreat of the sea which marked the opening of Yegua time. In view, however, of the apparent repetition at a number of localities of the unusual conditions demanded by such an interpretation, the absence of any stray organism suggesting the latter Claiborne, even in the foraminiferal and ostracod faunas and the imperfection of the floral evidence, the correlation of the Elm Creek fauna with the upper Claiborne invites criticism as a quibbling and sophistical solution. The implication in the commonly accepted terms "lower" and "upper" Claiborne may be misleading, since the lower Claiborne accounts for a very much longer time interval than the upper Claiborne. In fact, the upper Claiborne includes only the Gosport sand and its equivalents, while the lower Claiborne covers all of the formations from the Cane River to the Cook Mountain. The suggestion of the correlation of the Elm Creek faunas with the lower Claiborne by no means implies that they lived in the earlier half of Claiborne time.

The second interpretation of the Elm Creek faunas seems on the whole the more acceptable—that we have at the type locality of the Yegua a lower Claiborne fauna referable to lower Claiborne time, doubtless persisting to the very close of the lower Claiborne and profoundly influenced by the conditions attending the close. This fauna is present though in diminished numbers even to the top of the section. The flora at Elm Creek is very poorly preserved, and no determinable collections have ever been made from it, so that the relationship with the other so-called "Yegua floras" is based upon similarity of lithology and field relations rather than upon paleobotanical evidence. The correlation of the type section of the Yegua with the lower Claiborne may make it desirable to apply another name to the Yegua of Louisiana and Mississippi, the accepted time-equivalents of the Gosport sand of Alabama, but it should be remembered that Dumble included in the Yegua a considerable thickness of beds overlying the type section and covering a broad area to the northeast of them.

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